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HIGH-PRESSURE LIQUID AND GASEOUS OXYGEN IMPACT SENSITIVITY EVALUATION OF MATERIALS FOR USE AT KENNEDY SPACE CENTER

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Many materials will ignite or explode when in contact with gaseous oxygen (GOX) or liquid oxygen (LOX) if subjected to stimuli such as a mechanical impact, adiabatic compression (pneumatic impact), or an electrical discharge in the form of a spark. Such materials must therefore be characterized as to compatibility with LOX or GOX to define the degree of hazard with their use.

Generally, materials are more sensitive in gaseous oxygen than in liquid oxygen and impact sensitivity is known to increase with increasing pressure. Thus, the evaluation of the sensitivity of materials in GOX is required to supplement LOX impact test data. The testing program described in this report was initiated to evaluate materials presently being used or considered for use in oxygen systems at KSC. The ambient pressure LOX testing phase of this program was performed at KSC, the pressurized LOX testing at MSFC, the GOX mechanical impact testing at MSFC and WSTF, and the flash and fire point and pneumatic impact testing at WSTF.

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SUMMARY

Twelve materials were evaluated for reactivity in liquid oxygen, pressurized liquid oxygen, and high-pressure gaseous oxygen. These included an aluminum alloy (6061-T6), a polytetrafluoroethylene, four filled polytetrafluoroethylenes, a polyimide, a polychlorotrifluoroethylene, two fluoroelastomers, a perfluoroether base grease, and a nylon polymer.

INTRODUCTION

Many materials will ignite or explode when in contact with gaseous oxygen (GOX) or liquid oxygen (LOX) if subjected to stimuli such as a mechanical impact, adiabatic compression (pneumatic impact) or an electrical discharge in the form of a spark. Such materials must therefore be characterized as to compatibility with LOX or GOX to define the degree of hazard associated with their use as seals, gaskets, lubricants, etc.

The importance of characterizing materials as to compatibility with LOX and GOX is borne-out by a recent survey of oxygen related accidents in Great Britain. Fitt (ref. 1) reported on ten such accidents, approximately half of which were associated with aircraft. Although the exact cause was not always determined, the improper choice of materials was involved in approximately 50 percent of the cases. Similarly, Hust and Clark (ref. 2) recently surveyed reports on oxygen related accidents in NASA and the Department of Defense. A brief synopsis of their section on accident reports follows: McQuaid and Cole (ref. 3) found that an accident occurred in a Navy compressed gas system due to spontaneous ignition every four weeks on the average from January 1968 to May 1971. The proportion of these due to the

use of non-compatible materials was not reported, but some type of material failure was involved in approximately half of the incidents. Johnston (ref. 4) and Ordin (ref. 5) surveyed NASA, Air Force, and associated contractor records. Johnston reported that 56 percent of recorded incidents involved the use of oxygen incompatible materials. Ordin similarly reported that 20 percent of incidents with LOX and 36 percent of incidents with GOX involved the use of oxygen incompatible materials.

HISTORY OF THE DEVELOPMENT OF OXYGEN TESTING METHODS WITHIN NASA

In the late 1950's, Lucas and Riehl (ref. 6) devised a drop weight impact tester and test method for determining the impact sensitivity of materials in LOX. Current versions of this technique--MSFC-SPEC-106B (ref. 7), USAF Specification Bulletin 527 (ref. 8), and ASTM D 2512-70 (ref. 9)--use the same type of tester with only minor variations in testing and handling procedures to rate materials in terms of LOX impact sensitivity.

In the mid-1960's, Blackstone, Baber, and Ku (ref. 10) devised a test method which used mechanical impact as the stimulus, but did not attempt to determine minimum ignition levels. Instead, explosive shock pressure was measured when materials were impacted from a height known to produce ignition 50 percent of the time.

As a result of the January 1967 Apollo/Saturn 204 spacecraft fire on Launch Complex 34 at Kennedy Space Center (KSC), Marshall Space Flight Center (MSFC), and the White Sands Test Facility (WSTF) of the Johnson Spacecraft Center (JSC) placed major emphasis on development of methods for the evaluation of materials in pressurized GOX. While Nihart and Smith (ref. 11) and Baum, Goobich, and Trainer (ref. 12) had developed several GOX testing methods in the early 1960's, MSFC undertook the development of a method sufficiently similar to the LOX mechanical impact procedure to permit utilization of the extensive data base existing from 10 years of LOX impact testing.* Meanwhile, JSC undertook an evaluation of

*Prior to development of specific GOX testing methods, a material was considered to be qualified for use in GOX if it had been tested and approved for use in LOX by MSFC-SPEC-106B.

the flammability of spacecraft nonmetallic materials in oxygen environments up to 16.5 psia (11.2 x 10^4 N/m^2) pressure at WSTF (refs. 13 and 14). As an extension of this study, they developed a method for the determination of flash and fire points of materials in GOX to 3000 psia (20.6 x 10^6 N/m^2).

By 1969, MSFC had designed and built a mechanical impact tester for LOX or GOX at pressures up to 50 psia (34 x 10^4 N/m^2) (ref. 15). By 1971, this capability had been extended to pressures of 1500 psia (10.3 x 10^6 N/m^2) (ref. 16) and by 1972, to pressures of 10,000 psia (68 x 10^6 N/m^2) (ref. 17). Concurrently, WSTF designed and built a mechanical GOX impact device capable of testing materials to 10,000 psia (68 x 10^6 N/m^2) and a GOX pneumatic impact test device for the evaluation of materials up to this same pressure (ref. 18).

Different approaches resulted in minor variations in the apparatus and test methods developed at MSFC and WSTF. However, in 1972, the equipment, methods, and acceptance criteria for the evaluation of materials for use in oxygen systems were standardized, and procedures for offgassing analysis, toxicity tests, and evaluation of materials for use in propellant systems other than oxygen were defined (ref. 19).

About this same time, the testing program described in this report was initiated to evaluate materials presently being used or considered for use in oxygen systems at KSC. The ambient pressure LOX testing phase of this program was performed at KSC, the pressurized LOX impact testing at MSFC, the GOX mechanical impact testing at MSFC and WSTF, and the flash and fire point and pneumatic impact testing at WSTF.

MATERIALS

A survey of nonmetallic materials in KSC GOX and LOX systems revealed that only polytetrafluoroethylene (filled and unfilled), polychlorotrifluoroethylene, vinylidene/hexafluoropropylene polymerics, and a perfluoroalkyl ether based lubricant have been used extensively. Consequently, these materials were selected for this evaluation program. In addition, a metal (aluminum alloy 6061-T6), a known noncompatible polymer (a polyamide), and a polyimide with an unknown high-pressure GOX reactivity were chosen for evaluation.

All materials except the lubricant were procured and tested in two thicknesses, 0.125 inch (0.32 cm) and 0.0625 inch (0.16 cm). The tradenames and manufacturers of the various materials were as follows:

CLASS NAME	TRADE NAME	SOURCE
Aluminum	6061-T6 Alloy	KSC Central Supply
Fluoroelastomer	Fluorel E2160	Mosites Rubber Company, Compound Number 1059
Fluoroelastomer	Viton PLV 5010B	Pelmor Laboratories, Inc.
Perfluoroalkyl Ether Lubricant	Krytox 240AC	E. I. du Pont de Nemours & Company
Polyamide	Nylon 6/6 Alloy	Advanced Technology, Inc.
Polychlorotri-fluoroethylene	Kel-F-81	3M Company
Polyimide	Vespel SP-21	E. I. du Pont de Nemours & Company
Polytetrafluoro-ethylene	Teflon TFE	E. I. du Pont de Nemours & Company
Polytetrafluoro-ethylene (filled)	Fluorogold	Fluorocarbon Company
Polytetrafluoro-ethylene (filled)	Fluorogreen E600	John L. Dore Company
Polytetrafluoro-ethylene (filled)	Garlock 8573	Garlock, Inc.
Polytetrafluoro-ethylene (filled)	Rulon A	Dixon Corporation

MATERIALS CLEANING PROCEDURE

All of the materials (except the lubricant, Krytox 240AC, which was tested as received) were cleaned in the Technical

Services Department operated at KSC by the Bendix Launch Support Division, using the following procedure. The test specimens were brushed with a nylon brush in a flowing stream of inert gas to remove loose contamination, washed with deionized water containing a liquid detergent, rinsed in deionized water, and dried in a stream of inert gas. The test specimens were then packaged, 20 to a package, and sealed in heat-sealable bags. Personnel wore rubber gloves during the cleaning operation, and white low-lint nylon gloves when handling cleaned specimens.

GASEOUS AND LIQUID OXYGEN TEST PROCEDURES AND EQUIPMENT

The details of the test procedures and equipment used in this program are given in references 17 and 19. A brief description of the equipment and test procedures is presented in the following sections.

Ambient Pressure Liquid Oxygen Mechanical Impact Tests

These tests were performed at the KSC LOX Impact Test Facility. All materials were tested by subjecting them to 100 test drops in five groups of 20 specimens each. In this test procedure, a known amount of energy is transferred from an essentially free falling plummet to a striker pin resting directly on the test specimen immersed in LOX. The overall apparatus is shown in Figure 1 and the striker pin assembly is shown in Figure 2. For these particular tests, a 20 pound (9.09 kg) plummet was dropped from a height of 43.3 inches (1.1 m) onto a striker pin 0.5 inch (1.27 cm) in diameter, imparting an impact energy of 10 kg-m (7.72×10^5 J/m^2) to a 0.75 inch (1.90 cm) diameter test specimen. A reaction was indicated by an audible report, a visible flash (in a darkened room), and/or burning or charring of the test specimen.

High-Pressure Liquid Oxygen Mechanical Impact Tests

These tests were performed at MSFC using a special test cell (ref. 20), shown in Figure 3, inserted in the standard LOX impact test apparatus in place of the striker pin assembly. Since the apparatus was essentially soundproof, the only indication of a reaction was a visible flash and/or burning or charring of the test specimen.

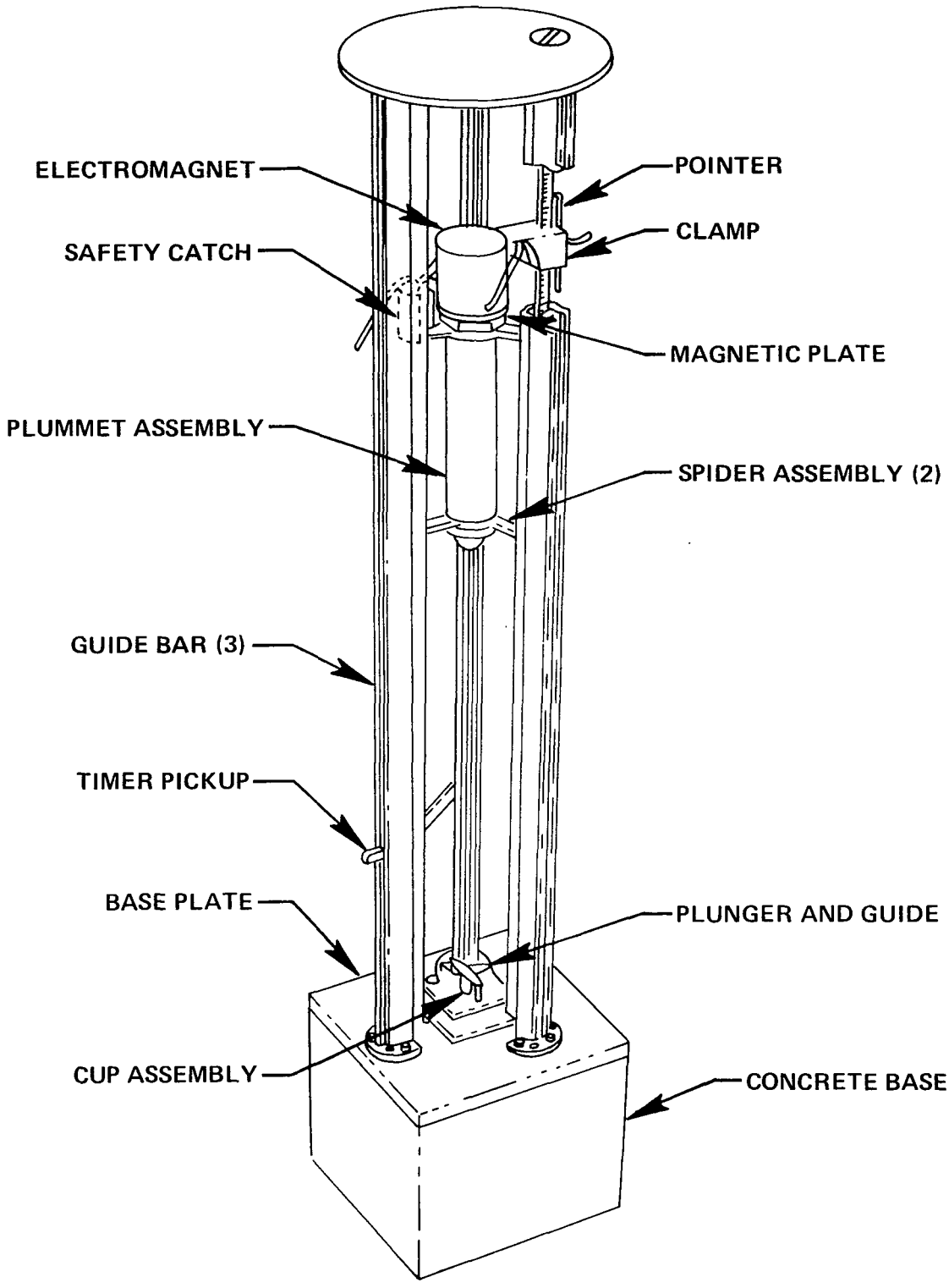


Figure 1. LOX Impact Sensitivity Tester

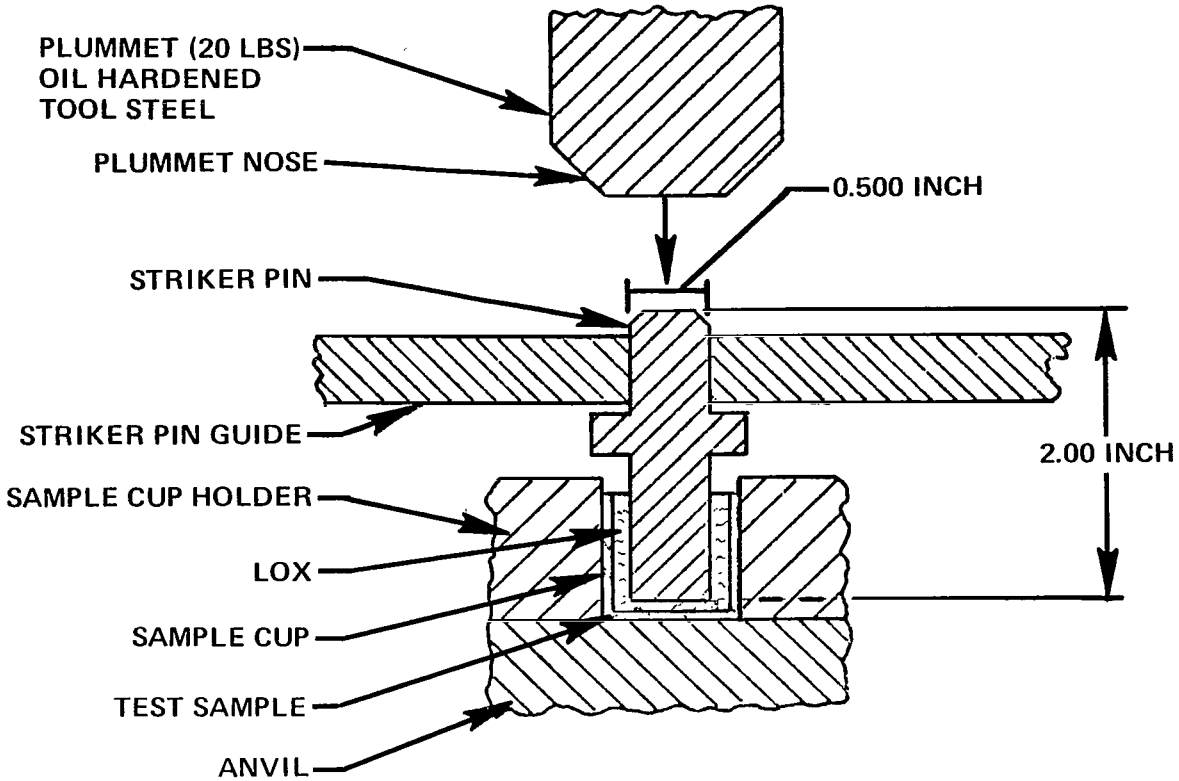


Figure 2. Striker, Cup, and Sample Arrangement of LOX Impact Sensitivity Tester

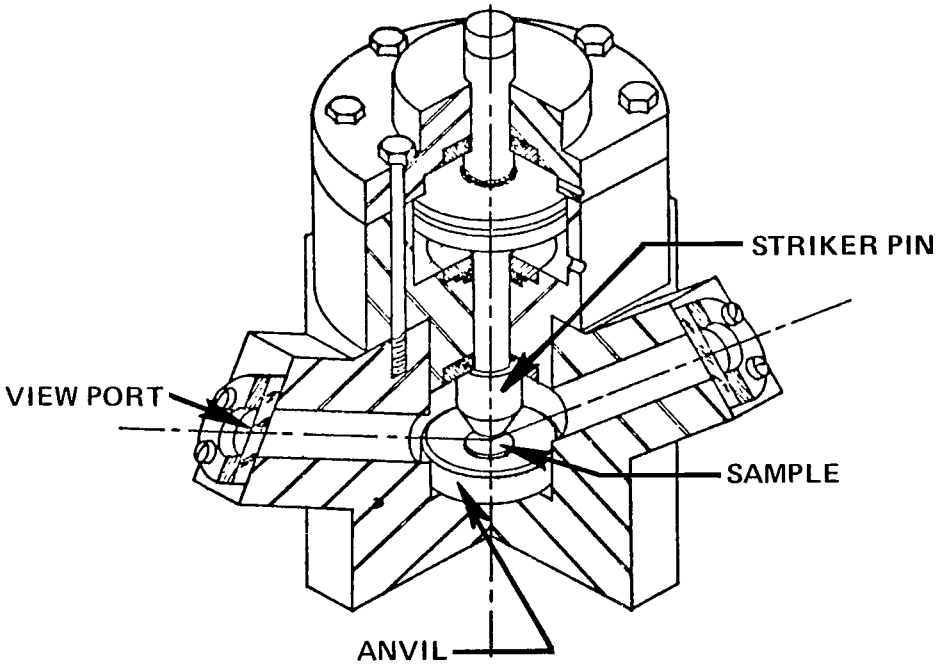


Figure 3. MSFC High-Pressure O_2 Tester

Twenty test drops each were performed on Viton PLV 5010B, Teflon TFE, Fluorogreen E600, Fluorogold, Rulon A, Garlock 8573, Vespel SP-21, and Kel-F at the 10 kg-m (7.72×10^5 J/m^2) energy level and at five different pressures:

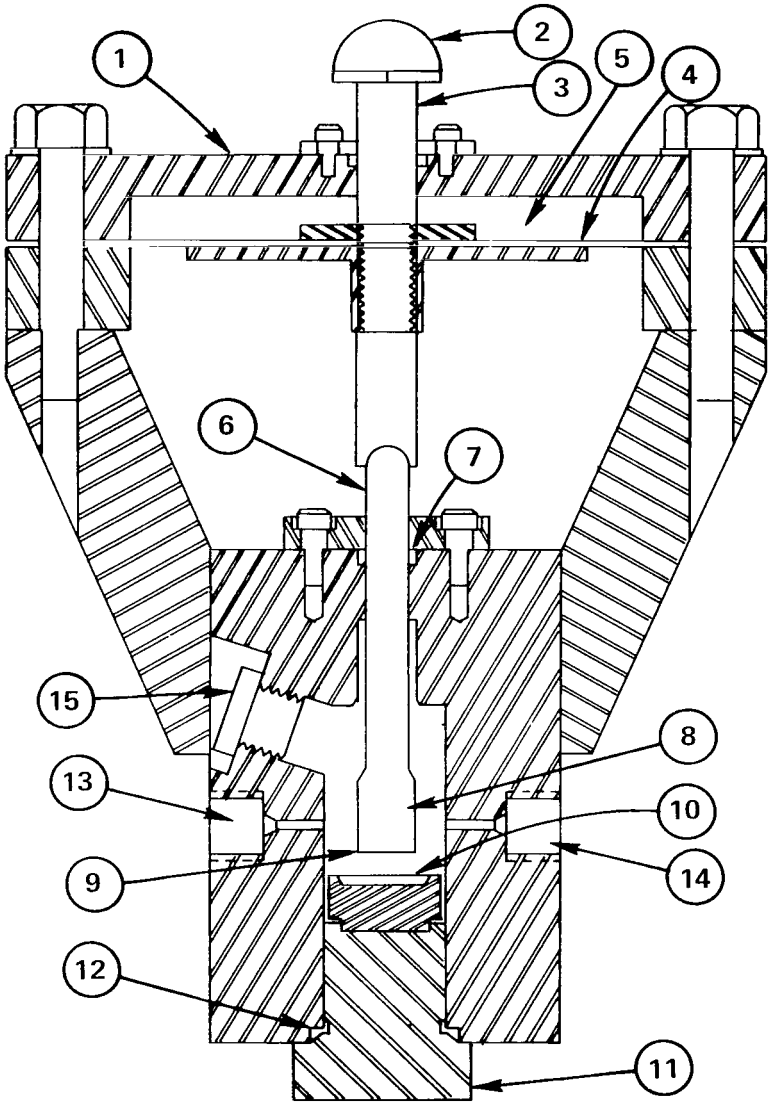
(psia)	N/m^2
(15)	10.3×10^4
(100)	68.0×10^4
(500)	3.4×10^6
(1000)	6.8×10^6
(1500)	10.3×10^6

High-Pressure Gaseous Oxygen Mechanical Impact Tests

High-pressure gaseous oxygen mechanical impact tests were performed at both MSFC and WSTF. The MSFC tests were performed using an apparatus similar to the pressurized LOX impact device (ref. 16) at the 10 kg-m (7.72×10^5 J/m^2) energy level. Except for the lowest pressure which was omitted, the pressures were the same as those used for the high-pressure liquid oxygen mechanical impact tests described above. Twenty test drops each were performed on both thicknesses of Viton PLV 5010B, Teflon TFE, Fluorogreen E600, Fluorogold, Rulon A, Garlock 8573, Vespel SP-21, and Kel-F.

Tests performed at WSTF provided data on the effects of variations in variables such as plummet weight, striker pin diameter, sample diameter, oxygen pressure, and impact energy. For these tests, the basic LOX impact tester was modified in the anvil region to accept a test chamber (Figure 4) designed to operate at pressures to 10,000 psia (68×10^6 N/m^2) (ref. 18). The chamber was monitored by a special optical system with a photocell which detects any increase in light intensity within the chamber and indicates this evidence of reaction on a cathode ray tube.

The object of this phase of the WSTF study was to determine the threshold energy level necessary for reaction of each material at the following pressures:



1	PNEUMATIC AMPLIFIER CHAMBER	9	HIGH PRESSURE CHAMBER
2	EQUALIZER PIN ANVIL	10	SAMPLE CUP
3	EQUALIZER PIN	11	ANVIL NUT
4	PNEUMATIC AMPLIFIER DIAPHRAGM	12	HIGH PRESSURE SEAL
5	PNEUMATIC AMPLIFIER CHAMBER GN_2 CAVITY	13	PRESSURIZATION PORT
		14	VENT PORT
6 & 8	STRIKER PIN	15	SIGHTGLASS FOR PHOTOCELL
7	HIGH PRESSURE SEAL		

Figure 4. WSTF Mechanical Impact Test Chamber

(psia)	N/m^2
(20)	13.6×10^4
(50)	34.0×10^4
(100)	68.0×10^4
(250)	1.7×10^6
(500)	3.4×10^6
(1000)	6.8×10^6
(1500)	10.3×10^6
(2000)	13.6×10^6
(3000)	20.6×10^6
(4000)	27.2×10^6
(5000)	34.0×10^6

To accomplish this, 5 basic and 8 intermediate energy levels were defined as follows:

Basic Energy Levels

(kg-m)	J/m^2
(10.0)	7.72×10^5
(7.6)	5.88×10^5
(5.5)	4.28×10^5
(3.5)	2.67×10^5
(1.4)	1.07×10^5

Intermediate Energy Levels

(kg-m)	J/m^2
(9.0)	6.94×10^5
(8.3)	6.38×10^5
(6.9)	5.33×10^5
(6.3)	4.84×10^5
(4.8)	3.72×10^5
(4.1)	3.16×10^5
(2.7)	2.11×10^5
(2.1)	1.61×10^5

Five impacts, each on previously untested samples, were performed at the lowest pressure and maximum impact energy level. If no reaction occurred, an additional 15 impacts were performed and if no reactions were observed, the testing was continued at the next higher pressure. When a reaction was

observed, the impact energy was decreased to the next lower basic energy level and 5 impacts performed at this level. If no reactions occurred, the energy level was then increased to the nearest intermediate impact energy level and 5 impacts performed.

If no reactions occurred at the first intermediate energy level, the impact energy was then increased to the next higher intermediate energy level and 5 impacts performed. If no reactions were observed at this second intermediate level, the impact energy was returned to the basic energy level of the initial reaction, and an additional 15 impacts performed. Thus, if the material reacted at one energy level but not at the next lower energy level, the threshold value for material reaction at that pressure was established and the procedure was then repeated at higher pressures until the threshold values for pressures up to 5000 psia (34 x 10^6 N/m^2) had been determined. This procedure is illustrated in the flow chart in Figure 5.

For some materials, two plummet weights and two striker pin diameters were used. A 20 pound (9.09 kg) plummet was used in conjunction with a 0.5 inch (1.27 cm) striker pin and a 7.5 pound (3.4 kg) plummet with 0.5 inch (1.27 cm) and 0.25 inch (0.63 cm) striker pins. Two sample diameters were also investigated. The standard 0.75 inch (1.90 cm) diameter test specimens were used with both sizes of striker pins and 0.25 inch (0.63 cm) diameter specimens with the 0.25 inch (0.63 cm) diameter striker pins.

High-Pressure Gaseous Oxygen Pneumatic Impact Tests

The theoretical temperature obtained in the adiabatic compression of a gas can be calculated. For example, the adiabatic compression of oxygen from ambient pressure to 5000 psia (34 x 10^6 N/m^2), the maximum pressure used for these tests, should raise the temperature to approximately 1277°C (1550 K) which is sufficient to ignite many materials in contact with the gas.

Pneumatic impact tests were performed at WSTF utilizing an apparatus with a high speed valve (1.8 milliseconds actuation time from fully closed to fully open) which, when actuated, caused oxygen to flow from a high pressure accumulator to the test sample cup shown in Figure 6 (ref. 18). Since the rate of pressurization of the cup was extremely fast, little heat transfer away from the system was possible and the resulting

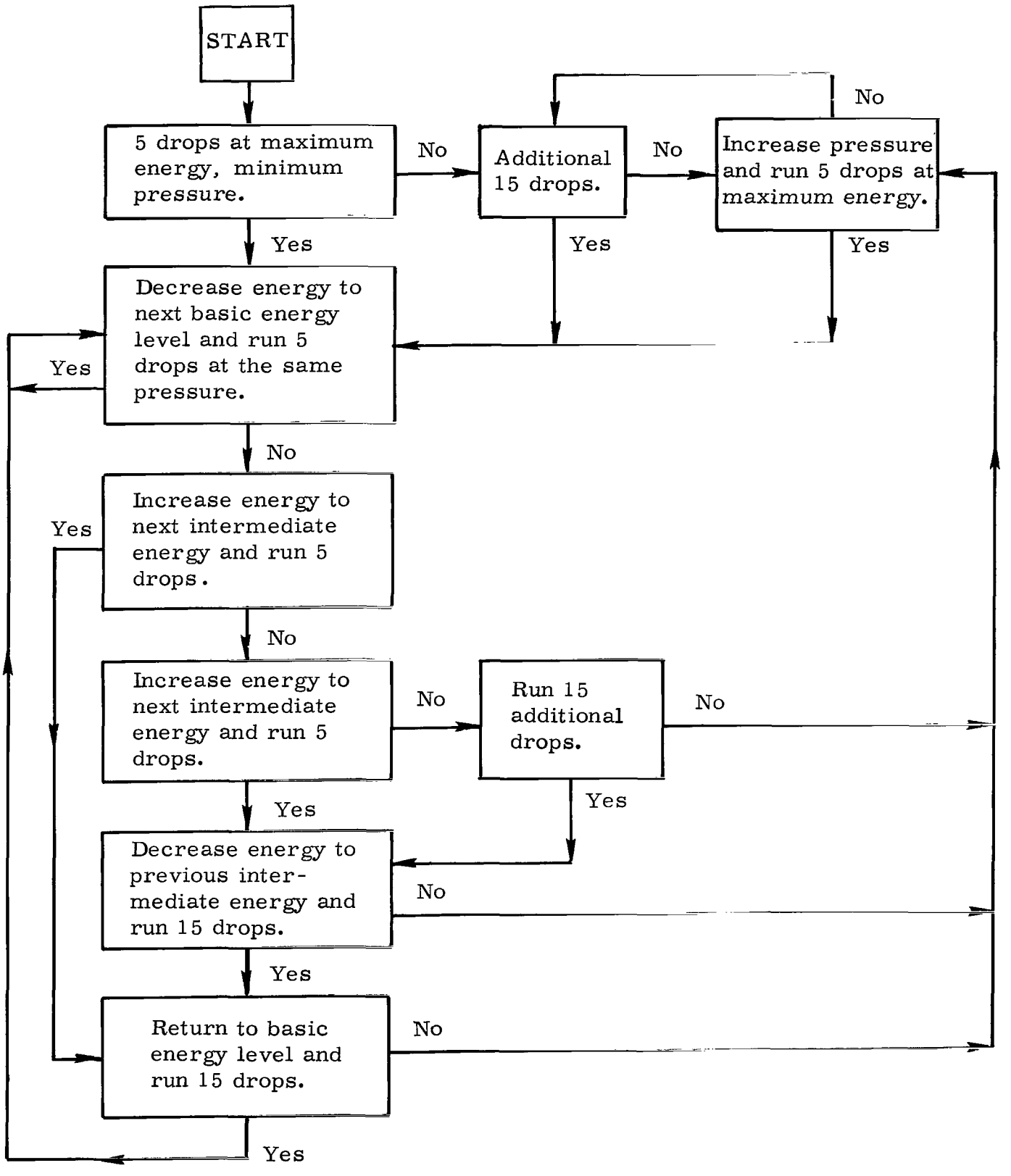


Figure 5. Test logic used in the WSTF GOX Mechanical Impact Tests

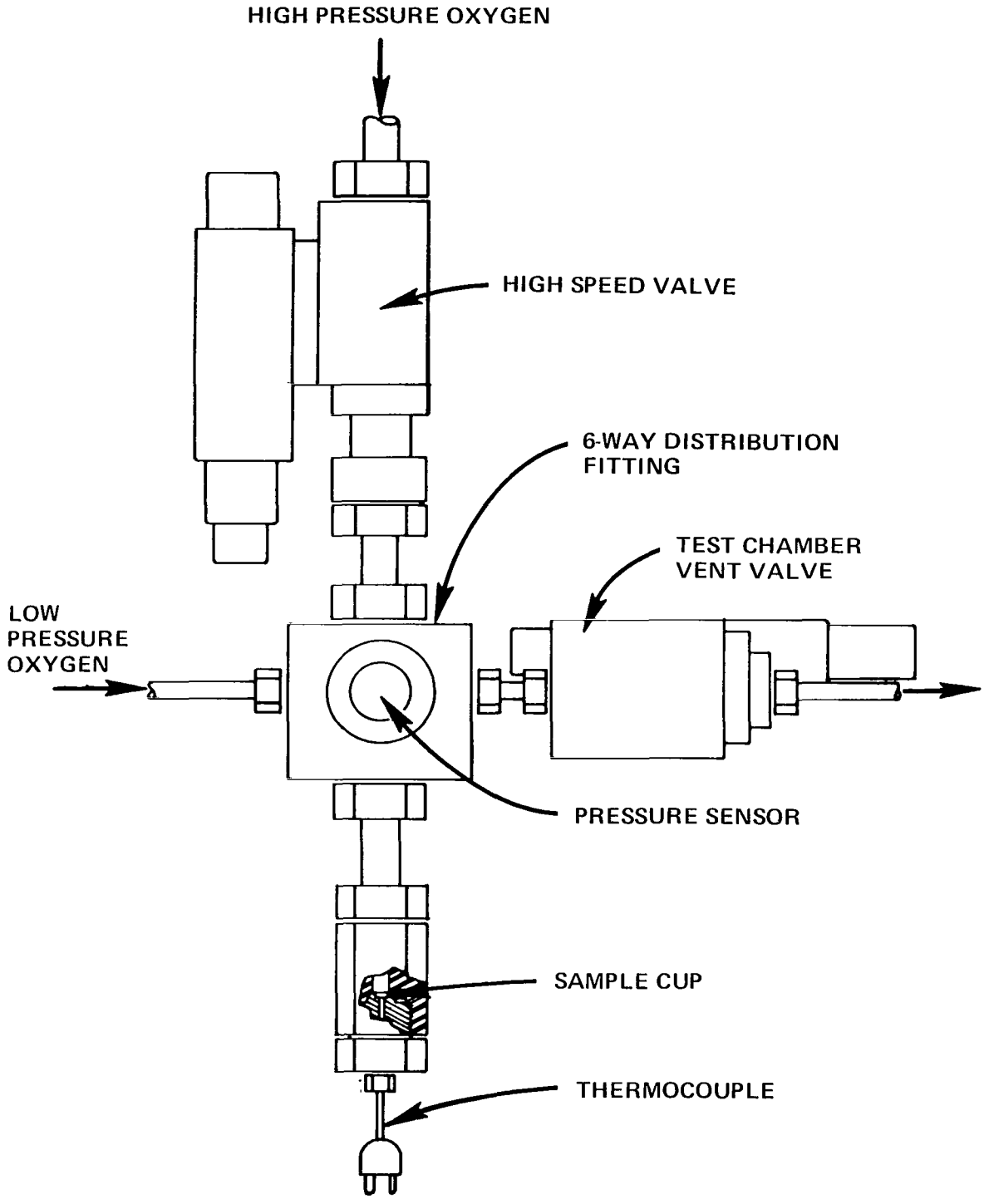


Figure 6. WSTF Pneumatic Impact Test System

temperatures should have approached those possible for an adiabatic process. These tests required the determination of a pressure level at which at least one reaction occurred in twenty samples followed by tests at the next lower pressure level at which no reactions were observed in twenty samples. Sample reactions were determined by observing a temperature increase of the sample cup thermocouple and by visually examining the sample or detecting an odor indicative of burning. The pressure levels were the same as used in the WSTF GOX mechanical impact tests.

High-Pressure Gaseous Oxygen Flash and Fire Point Testing

High pressure flash and fire point tests were conducted at WSTF utilizing a stainless steel chamber which could be heated at a fixed rate and was provided with an electronic readout to indicate reaction occurrence (ref. 18). Temperatures to 538°C (811 K) and pressures to 3000 psia (20.6 x 10^6 N/m^2) were employed (see Figure 7).

During testing, a 0.5 gm, 0.6 inch (1.5 cm) diameter sample of the test material was placed in the sample cup and the chamber sealed and pressurized to the desired test pressure with oxygen. The chamber temperature was then increased at the specified rate (usually 10°C per minute) and a high voltage electrical spark, 50 millijoules, was discharged 0.75 inch (1.9 cm) above the top of the sample at ten second intervals. When sufficient flammable volatiles had been emitted from the sample due to heating, a flash or fire resulted and was detected electronically by optically coupling the light intensity of the flash and/or fire to the photocell and converting this light to an electrical signal which was displayed on a storage oscilloscope. These tests were conducted at pressures ranging from 20 psia (13.6 x 10^4 N/m^2) to 3000 psia (20.6 x 10^6 N/m^2) in steps as shown previously (page10).

Chemical Analysis of the Test Samples

Samples of each test material were sent to the KSC Microchemical Analysis Laboratory to verify the chemical composition. Analytical methods included infrared and emission spectroscopy, thermal analysis, x-ray diffraction and fluorescence, and scanning electron microscopy.

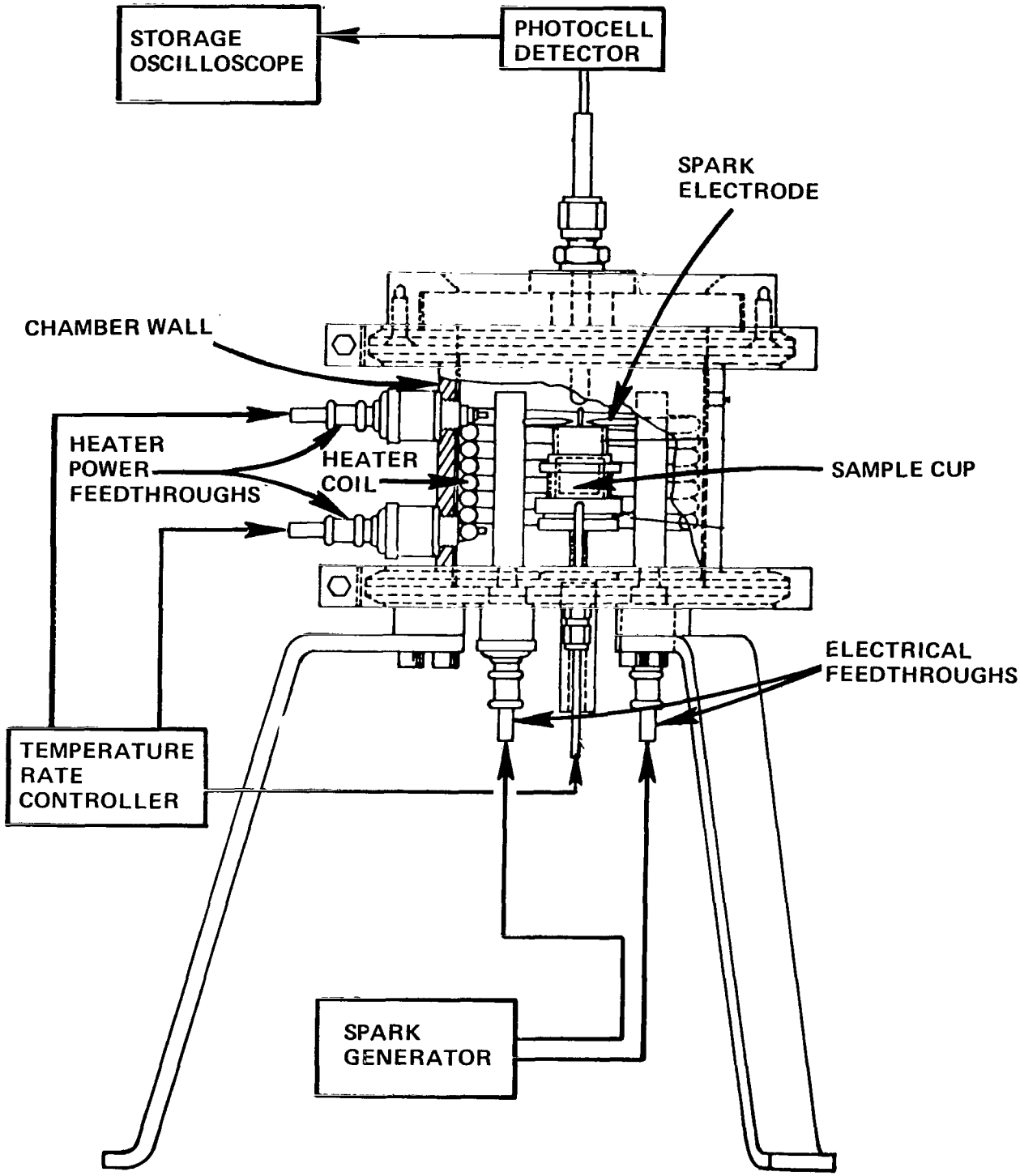


Figure 7. WSTF Flash & Fire Point Test Apparatus & Control System

DISCUSSION OF TEST RESULTS

The results for the 12 materials and various test methods are presented in Tables 1 through 55 and discussed below. In general, variations in reactivity between results for different materials or test methods are expressed in terms of threshold energy levels or frequencies of reaction at any given energy level and pressure.

Ambient Pressure Liquid Oxygen Mechanical Impact Tests

The results of the ambient pressure liquid oxygen impact tests conducted at KSC are summarized in Table 1. The nylon 6/6 alloy (which was included as a reactive reference material) was the only material which reacted under these test conditions.

High-Pressure Liquid Oxygen Mechanical Impact Tests

The results of the MSFC high-pressure liquid oxygen mechanical impact tests at 10 kg-m (7.72×10^5 J/m^2) are summarized in Table 2. Viton PLV 5010B was found to be reactive in both thicknesses with threshold pressures of 1000 psia (6.8×10^6 N/m^2) for the 0.0625 inch (0.16 cm) thickness and 500 psia (3.4×10^6 N/m^2) for the 0.125 inch (0.32 cm) thickness.

Although Fluorel E2160 was not tested, it is known to be similar chemically to the Viton elastomer, and would be expected to exhibit reactions under these test conditions. The nylon 6/6 alloy was not tested since it was known to be reactive under ambient LOX pressure and it was felt that a serious damage potential to the test apparatus existed. The fluorinated lubricant, Krytox 240AC, was not evaluated since it had been tested previously and found to be nonreactive in both LOX and GOX at pressures to 1500 psia (10.3×10^6 N/m^2) (ref. 20).

High-Pressure Gaseous Oxygen Mechanical Impact Tests

The results of the GOX mechanical impact tests conducted at MSFC are summarized in Table 3. Reactions were observed for

Viton PLV 5010B and Vespel SP-21 at 500 psia (3.4×10^6 N/m^2) for the 0.0625 inch (0.16 cm) specimens and at 1000 psia (6.8×10^6 N/m^2) for the 0.125 inch (0.32 cm) specimens.

High-Pressure Gaseous Oxygen Mechanical Impact Tests

The results of the WSTF GOX mechanical impact tests are summarized in Tables 4 through 49. The results for each material are discussed separately and include all variations of plummet weight, striker pin, diameter, and sample thickness investigated. In these discussions, the term "standard configuration" will be used to denote the 20 pound (9.09 kg) plummet with the 0.5 inch (1.27 cm) diameter striker pin and 0.75 inch (1.90 cm) diameter test specimens.

Krytox 240AC. The results in Tables 4 and 5 summarize the tests performed with the standard configuration and with the 7.5 pound (3.4 kg) plummet/0.25 inch (0.63 cm) striker pin combination, respectively. The sample thickness for all tests was 0.005 inch (0.013 cm). No reactions were observed.

Teflon TFE. Teflon TFE did not react in standard configuration tests in the 0.125 inch (0.32 cm) thickness (see Table 6). However, reactions were observed with the 0.0625 inch (0.16 cm) thick material at a pressure of 5000 psia (34×10^6 N/m^2) and an impact energy of 10 kg-m (7.72×10^5 J/m^2) (see Table 7). One reaction was also observed using the 7.5 pound (3.4 kg) plummet and 0.25 inch (0.63 cm) striker pin with a 0.0625 inch (0.16 cm) thick specimen at a pressure of 4000 psia (27.2×10^6 N/m^2) and an impact energy of 10 kg-m (7.72×10^5 J/m^2) (see Table 8). However, tests with other combinations of material thickness, specimen diameter, pressure, and impact energy failed to produce any reactions (see Tables 9 through 11).

All reactions were characterized by the lack of residue and the presence of a mild, undefined odor.

Garlock 8573. The test results for Garlock 8573 using the standard test configuration are summarized in Tables 12 and 13. The 0.0625 inch (0.16 cm) thick specimens reacted at a pressure of 1000 psia (6.8×10^6 N/m^2) and an impact energy of 10 kg-m (7.72×10^5 J/m^2). The 0.125 inch (0.32 cm) thick specimens reacted at a pressure of 2000 psia (13.6×10^6 N/m^2) and an impact energy of 4.8 kg-m (3.72×10^5 J/m^2). The increase in reactivity with increasing pressure was more pronounced for the thinner specimens.

A white ash, a considerable amount of white smoke, and a strong odor were noted in most reactions with this material.

Fluorogreen E600. With the standard test configuration, 0.0625 inch (0.16 cm) thick Fluorogreen E600 (see Table 14) reacted at a pressure of 1000 psia (6.8×10^6 N/m^2) and an impact energy of 7.6 kg-m (5.88×10^5 J/m^2). From this point, the frequency of reactions at a given energy level tended to increase with pressure.

Fluorogreen E600 in the 0.125 inch (0.32 cm) thickness (table 15) also reacted at the 1000 psia (6.8×10^6 N/m^2) pressure level but only at the full impact energy level of 10 kg-m (7.72×10^5 J/m^2).

A sharp odor with very little smoke was observed in these reactions. A white ash or yellow-gold residue usually remained.

Rulon A. Using the standard test configuration, the 0.0625 inch (0.16 cm) thick Rulon A initially reacted at a pressure of 1500 psia (10.3×10^6 N/m^2) and an impact energy of 3.5 kg-m (2.67×10^5 J/m^2) (see Table 16). The 0.125 inch (0.32 cm) thick material reacted initially at a pressure of 1500 psia (10.3×10^6 N/m^2) and an impact energy of 6.3 kg-m (4.84×10^5 J/m^2).

Generally, only the portion of the specimen under the striker pin burned, leaving a white ash with red-brown particles. Very little smoke or odor was observed.

Fluorogold. Fluorogold reacted initially at a pressure of 1500 psia (10.3×10^6 N/m^2) and an impact energy of 8.3 kg-m (6.38×10^5 J/m^2) using the standard test configuration with 0.0625 inch (0.16 cm) thick samples. Subsequent tests showed a rapid decrease in threshold energy with increasing pressure. (See Table 18.) The thicker, 0.125 inch (0.32 cm) specimens, reacted in a similar manner (see Table 19).

The residue from reacted samples was a white ash in most cases. A strong odor was associated with these reactions.

Kel-F. This material, in the 0.0625 inch (0.16 cm) thickness and using the standard test configuration, reacted initially at a pressure of 1500 psia (10.3×10^6 N/m^2) and an impact energy of 6.9 kg-m (5.33×10^5 J/m^2) (see Table 20). The 0.125 inch (0.32 cm) material reacted at a pressure of 1000 psia (6.8×10^6 N/m^2) and an impact energy level of 10 kg-m (7.72×10^5 J/m^2) (see Table 21).

No residue was found after reactions were observed and the striker pins and sample cups were stained black.

Vespel SP-21. With the standard test configuration, the 0.0625 inch (0.16 cm) thick material reacted at a pressure of 100 psia (68×10^4 N/m^2) and an impact energy of 7.6 kg-m (5.88×10^5 J/m^2). The 0.125 inch (0.32 cm) thick material reacted initially at a pressure of 3000 psia (20.6×10^6 N/m^2) and an impact energy of 10 kg-m (7.72×10^5 J/m^2). The threshold energy level decreased with increasing pressure above this point for both thicknesses (see Tables 22 and 23).

Several tests were performed on this material in both thicknesses and specimen diameters with the 7.5 pound (3.4 kg) plummet and 0.25 inch (0.63 cm) striker pins. The 0.0625 inch (0.16 cm) thick material exhibited a lower threshold energy level for the 0.25 inch (0.63 cm) diameter specimens than that for the 0.88 inch (2.22 cm) diameter specimens. However, the reverse of this was noted for the 0.125 inch (0.32 cm) thick material (see Tables 24 through 27).

Vespel SP-21 reactions were generally characterized by moderate to strong odor and a charred black residue, somewhat similar to coal or charcoal in appearance. Some unconsumed material was generally found under the striker pin.

Nylon 6/6 Alloy. The 0.0625 inch (0.16 cm) thick material reacted initially at a pressure of 500 psia (3.4×10^6 N/m^2) and an impact energy of 7.6 kg-m (5.88×10^5 J/m^2) using the standard test configuration (see Table 28). The initial reaction for the thicker material occurred at a lower pressure of 250 psia (1.7×10^6 N/m^2) (see Table 29).

Tests with the 7.5 pound (3.4 kg) plummet and 0.25 inch (0.63 cm) striker pin system were performed only at the higher pressures. The smaller diameter specimens, 0.25 inch (0.63 cm), were found to have lower threshold energy levels in both thicknesses (see Tables 30 through 33).

A moderate amount of brown to black residue accompanied by a mild odor was generally observed for all reactions.

Viton PLV 5010B. Using the standard test configuration with 0.0625 inch (0.16 cm) thick material, the first reaction occurred at a pressure of 500 psia (3.4×10^6 N/m^2) and an impact energy of 7.6 kg-m (5.88×10^5 J/m^2) (see Table 34). The thicker material reacted initially at a higher pressure (see Table 35). Both thicknesses of material showed little variation in threshold energy level with increasing pressure.

Tests performed with the 7.5 pound (3.4 kg) plummet and 0.25 inch (0.63 cm) striker pin system showed little variation of threshold energy level with sample diameter in either thickness (see Tables 36 through 39).

A strong odor was noted for most reactions observed. The residue varied from none, to mixed black and white, to all white.

Fluorel E2160. With the standard test configuration, 0.0625 inch (0.16 cm) thick Fluorel E2160 exhibited an impact energy threshold of 10 kg-m (7.72×10^5 J/m^2) which decreased to roughly 4.1 kg-m (3.16×10^5 J/m^2) as the pressure was increased from 250 psia (1.7×10^6 N/m^2) to 5000 psia (34.0×10^6 N/m^2) (see Table 40).

The 0.125 inch (0.32 cm) thick material first reacted at a pressure of 500 psia (3.4×10^6 N/m^2) and an impact energy level of 6.9 kg-m (5.33×10^5 J/m^2). The threshold energy level remained essentially constant as the pressure was increased (see Table 41).

Higher pressures were required to obtain reactions using the 7.5 pound (3.4 kg) plummet and 0.25 inch (0.63 cm) striker pin system. In fact, a pressure of 3000 psia (20.6×10^6 N/m^2) was required before reactions were obtained with either diameter specimen in either thickness (see Tables 42 through 45).

Reactions with Fluorel E2160 were generally characterized by a grayish-white residue and mild to strong odor.

Aluminum Alloy 6061-T6. One reaction was obtained with aluminum alloy 6061-T6 (see Tables 46 through 49). This reaction occurred using the standard test configuration with the 0.0625 inch (0.16 cm) thick material at a pressure of 2000 psia (13.6×10^6 N/m^2) and an impact energy level of 10 kg-m (7.72×10^5 J/m^2). Reactions with aluminum Tens-50 alloy have previously been reported using a similar test configuration (ref. 20).

High-Pressure Gaseous Oxygen Pneumatic Impact Tests

The results of the WSTF gaseous oxygen pneumatic impact tests are summarized in Tables 50 and 51. Aluminum alloy 6061-T6 was the only material found to be non-reactive at the maximum test pressure, 5000 psia (34×10^6 N/m^2).

Viton PLV 5010B and Fluorel E2160 exhibited different reactivities in these tests as compared to the mechanical impact tests where their reactivities were essentially the same. Fluorel E2160 had lower threshold pressures in both thicknesses than Viton PLV 5010B.

Krytox 240AC, which was non-reactive in the mechanical impact tests, reacted at 1000 psia (6.8 x 10^6 N/m^2) as did the 0.0625 inch (0.16 cm) thick Kel-F and both thicknesses of Nylon 6/6 alloy.

Materials which reacted at 1500 psia (10.3 x 10^6 N/m^2) include 0.0625 inch (0.16 cm) thick Fluorogold, 0.125 inch (0.32 cm) thick Kel-F, and Fluorogreen E600. Teflon TFE, 0.125 inch (0.32 cm) thick, and Rulon A, 0.0625 inch (0.16 cm) thick, both reacted at a pressure of 2000 psia (13.6 x 10^6 N/m^2). Fluorogold, 0.125 inch (0.32 cm) thick, reacted at a pressure of 3000 psia (20.6 x 10^6 N/m^2).

Vespel SP-21, 0.125 inch (0.32 cm) thick, and Fluorogreen E600, 0.0625 inch (0.16 cm) thick, reacted at 4000 psia (27.2 x 10^6 N/m^2). Materials observed to react at 5000 psia (34 x 10^6 N/m^2) include the 0.0625 inch (0.16 cm) thick Teflon TFE, Garlock 8573, Vespel SP-21, and the 0.125 inch (0.32 cm) thick Rulon A and Garlock 8573.

High-Pressure Gaseous Oxygen Flash and Fire Point

The WSTF high-pressure flash point test results are summarized in Tables 52 and 53, and the fire point test results are summarized in Tables 54 and 55. Only aluminum alloy 6061-T6 exhibited no flash or fire point under any of the test conditions.

Chemical Analysis of the Test Materials

The basic resins of the polymeric materials and the single lubricant were verified by infrared techniques as being the proper composition. Detailed analysis of the four filled polytetrafluoroethylenes revealed a filler content ranging from 20 to 27 percent by weight. Scanning electron photomicrographs showed these four materials to contain fiber-like fillers (see Figure 8) which were identified as amorphous SiO_2 (glass), and other minerals, including rutile (TiO_2). The nylon material was identified as primarily nylon 6/6 with a small amount of another polyamide.

The aluminum alloy 6060-T6 was found to have the correct composition and hardness.

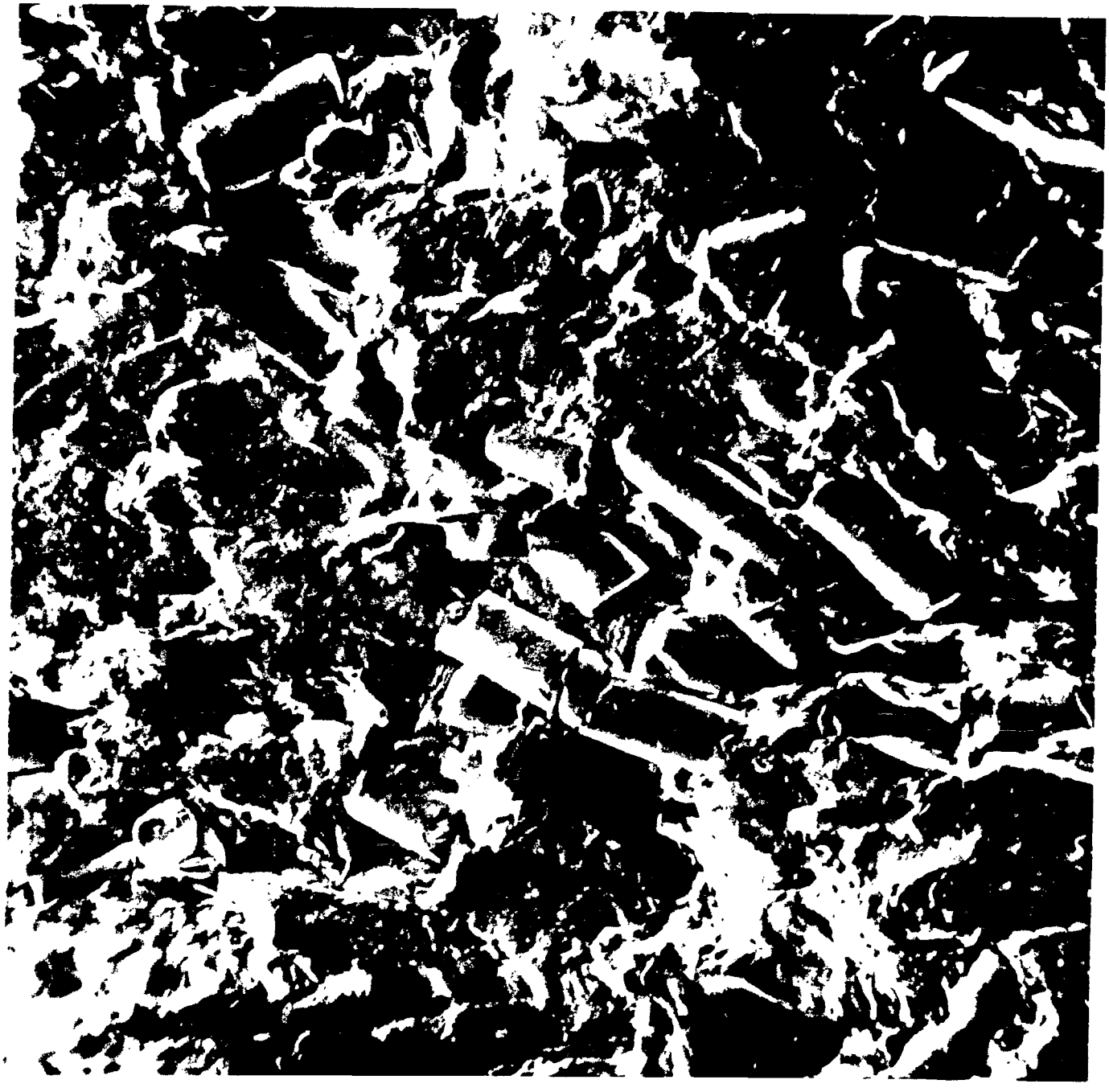


Figure 8. Scanning Electron Photomicrograph of Glass Fiber Filler in One of the Filled Polytetrafluoroethylenes (Magnification 1000X 12° Red Disk)

CONCLUSIONS

The purpose of this testing program was to study the reactivity of selected materials under ambient LOX, pressurized LOX, and high-pressure GOX conditions. These materials, with the exception of the nylon 6/6 alloy, were being used or being considered for use in KSC oxygen systems.

The KSC LOX impact test results were generally consistent with those for previous tests. The MSFC and WSTF GOX mechanical impact test results were also consistent with previous results in that the threshold energy levels generally decreased with increasing pressure.

In the study of the different test geometries at WSTF, an increased reactivity was generally noted with the larger striker pin and specimen size as required by the standard test configuration. This increase in reactivity with striker pin diameter agrees with results reported by Blackstone, Baber, and Ku (ref. 10).

The WSTF program also indicated a higher reactivity for the filled polytetrafluoroethylenes than for the unfilled resin. These fillers probably act in several different ways to increase the reactivity of the material. One possibility is the inadvertent contamination of the resin with a foreign substance contained in the filler material, such as the sizing used on the glass fiber. Also, since the fillers are added to improve the creep or cold flow characteristics of the resin, the increased stiffness may decrease the amount of energy dissipated through deformation. Another possibility is the generation of "hot-spots" due to increased internal friction as a result of the filler material rubbing or moving during deformation.

The pneumatic impact tests at WSTF produced reactions for every test material except aluminum alloy 6061-T6. No obvious relationship between sample thickness and threshold pressure was observed.

All materials except aluminum alloy 6061-T6 exhibited a flash or fire point at some pressure. The flash or fire point temperatures generally decreased with increasing pressure, and the reactions become more violent as the pressure increased.

A comparison of results for GOX mechanical impact tests at 10 kg-m (7.72×10^5 J/m^2) indicated generally higher pressure thresholds for MSFC tests than for WSTF tests. However, insufficient information regarding the precision of results is available to indicate whether these differences are significant.

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October 31, 1975

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DATA TABLES

TABLE 1 - KSC LOX IMPACT TEST RESULTS

(Number of Reactions per 100 Test Drops)

LUBRICANTS	POLYMERS	
Krytox 240AC - 0	Nylon 6/6 Alloy	Rulon A
	0.16 cm Thick - 3	0.16 cm Thick - 0
ELASTOMERS	0.32 cm Thick - 1	0.32 cm Thick - 0
Viton PLV 5010B	Vespel SP-21	Fluorogreen E600
0.16 cm Thick - 0	0.16 cm Thick - 0	0.16 cm Thick - 0
0.32 cm Thick - 0	0.32 cm Thick - 0	0.32 cm Thick - 0
Fluorel E2160	Teflon TFE	Garlock 8573
0.16 cm Thick - 0	0.16 cm Thick - 0	0.16 cm Thick - 0
0.32 cm Thick - 0	0.32 cm Thick - 0	0.32 cm Thick - 0
METALS	Fluorogold	KEL-F
	0.16 cm Thick - 0	0.16 cm Thick - 0
Aluminum 6061-T6	0.32 cm Thick - 0	0.32 cm Thick - 0
0.16 cm Thick - 0		
0.32 cm Thick - 0		

TABLE 2 - MSFC PRESSURIZED LOX MECHANICAL TEST RESULTS

(Number of Reactions in 20 Test Drops)

ELASTOMERS	POLYMERS	
Viton PLV 5010B	Teflon TFE	Garlock 8573
0.16 cm Thick 10.3×10^4 N/m^2 - 0 68.0×10^4 N/m^2 - 0 3.4×10^6 N/m^2 - 0 6.8×10^6 N/m^2 - 2 10.3×10^6 N/m^2 - 2	0.16 cm Thick 10.3×10^6 N/m^2 - 0	0.16 cm Thick 10.3×10^6 N/m^2 - 0
0.32 cm Thick 10.3×10^4 N/m^2 - 0 68.0×10^4 N/m^2 - 0 3.4×10^6 N/m^2 - 3 6.8×10^6 N/m^2 - 4 10.3×10^6 N/m^2 - 6	0.32 cm Thick 10.3×10^6 N/m^2 - 0	0.32 cm Thick 10.3×10^6 N/m^2 - 0
	Fluorogreen E600	KEL-F
	0.16 cm Thick 10.3×10^6 N/m^2 - 0	0.16 cm Thick 10.3×10^6 N/m^2 - 0
	0.32 cm Thick 10.3×10^6 N/m^2 - 0	0.32 cm Thick 10.3×10^6 N/m^2 - 0
	Fluorogold	Vespel SP-21
	0.16 cm Thick 10.3×10^6 N/m^2 - 0	0.16 cm Thick 10.3×10^6 N/m^2 - 0
	0.32 cm Thick 10.3×10^6 N/m^2 - 0	0.32 cm Thick 10.3×10^6 N/m^2 - 0
	Rulon A	
	0.16 cm Thick 10.3×10^6 N/m^2 - 0	
	0.32 cm Thick 10.3×10^6 N/m^2 - 0	

TABLE 3 - MSFC PRESSURIZED GOX MECHANICAL IMPACT TEST RESULTS

(Number of Reactions in 20 Test Drops)

ELASTOMERS	POLYMERS	
Viton PLV 5010B	Teflon TFE	Garlock 8573
0.16 cm Thick 68.0×10^4 N/m^2 - 0 3.4×10^6 N/m^2 - 5 6.8×10^6 N/m^2 - 20 10.3×10^6 N/m^2 - 20	0.16 cm Thick 10.3×10^6 N/m^2 - 0	0.16 cm Thick 10.3×10^6 N/m^2 - 0
0.32 cm Thick 68.0×10^4 N/m^2 - 0 3.4×10^6 N/m^2 - 0 6.8×10^6 N/m^2 - 20 10.3×10^6 N/m^2 - 20	0.32 cm Thick 10.3×10^6 N/m^2 - 0	0.32 cm Thick 10.3×10^6 N/m^2 - 0
	Fluorogreen E600	KEL-F
	0.16 cm Thick 10.3×10^6 N/m^2 - 0	0.16 cm Thick 10.3×10^6 N/m^2 - 0
	0.32 cm Thick 10.3×10^6 N/m^2 - 0	0.32 cm Thick 10.3×10^6 N/m^2 - 0
	Fluorogold	Vespel SP-21
	0.16 cm Thick 10.3×10^6 N/m^2 - 0	0.16 cm Thick 68.0×10^4 N/m^2 - 0 3.4×10^6 N/m^2 - 9 6.8×10^6 N/m^2 - 16 10.3×10^6 N/m^2 - 20
	0.32 cm Thick 10.3×10^6 N/m^2 - 0	0.32 cm Thick 68.0×10^4 N/m^2 - 0 3.4×10^6 N/m^2 - 0 6.8×10^6 N/m^2 - 7 10.3×10^6 N/m^2 - 14
	Rulon A	
	0.16 cm Thick 10.3×10^6 N/m^2 - 0	
	0.32 cm Thick 10.3×10^6 N/m^2 - 0	

WSTF Pressurized GOX Mechanical Impact Test Results

TABLE 4

MATERIAL: KRYTOX 240AC

Plummet Wt.: 9.09 kg **Sample Dia.:**

Striker Pin Dia.: 1.27 cm **Sample Thickness:** .0127 cm

Test Atmosphere: 100% O_2

NUMBER OF REACTIONS/NUMBER OF TESTS

ENERGY IMPACT - Joules per square meter	PRESSURE - Newton per square meter									
	13.6 X 10^4	68.0 X 10^4	1.7 X 10^6	3.4 X 10^6	6.8 X 10^6	10.3 X 10^6	13.6 X 10^6	20.6 X 10^6	27.2 X 10^6	34.8 X 10^6
1.07 X 10^5										
1.61 X 10^5										
2.11 X 10^5										
2.67 X 10^5										
3.16 X 10^5										
3.72 X 10^5										
4.28 X 10^5										0/5
4.84 X 10^5										
5.33 X 10^5										
5.88 X 10^5										0/5
6.38 X 10^5										
6.94 X 10^5										
7.72 X 10^5										0/20

WSTF Pressurized GOX Mechanical Impact Test Results

TABLE 5

MATERIAL: KRYTOX 240AC

Plummet Wt.: 3.4 kg

Striker Pin Dia.: 0.63 cm

Test Atmosphere: 100% O_2

Sample Dia.:

Sample Thickness: .0127 cm

NUMBER OF REACTIONS/NUMBER OF TESTS

ENERGY IMPACT - Joules per square meter	PRESSURE - Newton per square meter									
	13.6 X 10^4	68.0 X 10^4	1.7 X 10^6	3.4 X 10^6	6.8 X 10^6	10.3 X 10^6	13.6 X 10^6	20.6 X 10^6	27.2 X 10^6	34.0 X 10^6
1.07 X 10^5							0/5	0/5	0/5	0/5
1.61 X 10^5										
2.11 X 10^5										
2.67 X 10^5							0/5	0/5	0/5	0/5 0/5
3.16 X 10^5										
3.72 X 10^5										
4.28 X 10^5							0/5	0/5	0/5	*
4.84 X 10^5										
5.33 X 10^5										
5.88 X 10^5							0/5	0/5	0/5	*
6.38 X 10^5										
6.94 X 10^5										
7.72 X 10^5							0/20	0/20	0/20	**

* 0/5
0/5
0/5

** 0/20
0/20
0/20

WSTF Pressurized GOX Mechanical Impact Test Results

TABLE 6

MATERIAL: TEFLON TFE

Plummet Wt.: 9.09 kg

Striker Pin Dia.: 1.27 cm

Test Atmosphere: 100% O_2

Sample Dia.: 1.90 cm

Sample Thickness: 0.32 cm

NUMBER OF REACTIONS/NUMBER OF TESTS

ENERGY IMPACT - Joules per square meter	PRESSURE - Newton per square meter									
	13.6 X 10^4	68.0 X 10^4	1.7 X 10^6	3.4 X 10^6	6.8 X 10^6	10.3 X 10^6	13.6 X 10^6	20.6 X 10^6	27.2 X 10^6	34.0 X 10^6
1.07 X 10^5										
1.61 X 10^5										
2.11 X 10^5										
2.67 X 10^5										
3.16 X 10^5										
3.72 X 10^5										
4.28 X 10^5										
4.84 X 10^5										
5.33 X 10^5										
5.88 X 10^5										
6.38 X 10^5										
6.84 X 10^5										
7.72 X 10^5									0/20	0/20

WSTF Pressurized GOX Mechanical Impact Test Results

TABLE 7

MATERIAL: TEFLON TFE

Plummet Wt.: 9.09 kg

Striker Pin Dia.: 1.27 cm

Test Atmosphere: 100% O_2

Sample Dia.: 1.90 cm

Sample Thickness: 0.16 cm

NUMBER OF REACTIONS/NUMBER OF TESTS

ENERGY IMPACT - Joules per square meter	PRESSURE - Newton per square meter									
	13.6 X 10^4	68.0 X 10^4	1.7 X 10^6	3.4 X 10^6	6.8 X 10^6	10.3 X 10^6	13.6 X 10^6	20.6 X 10^6	27.2 X 10^6	34.0 X 10^6
1.07 X 10^5										
1.61 X 10^5										
2.11 X 10^5										
2.67 X 10^5										
3.16 X 10^5										
3.72 X 10^5										
4.28 X 10^5										
4.84 X 10^5										
5.33 X 10^5										
5.88 X 10^5								0/5		
6.38 X 10^5										
6.84 X 10^5										
7.72 X 10^5					0/5	0/5	0/5	0/20	0/20 0/20	4/20 0/20

WSTF Pressurized GOX Mechanical Impact Test Results

TABLE 8

MATERIAL : TEFLON TFE

Plummet Wt.: 3.4 kg

Striker Pin Dia.: 0.63 cm

Test Atmosphere: 100% O_2

Sample Dia.: 0.63 cm

Sample Thickness: 0.16 cm

NUMBER OF REACTIONS/NUMBER OF TESTS

ENERGY IMPACT - Joules per square meter	PRESSURE - Newton per square meter									
	13.6 X 10^4	68.0 X 10^4	1.7 X 10^6	3.4 X 10^6	6.8 X 10^6	10.3 X 10^6	13.6 X 10^6	20.6 X 10^6	27.2 X 10^6	34.0 X 10^6
1.07 X 10^5										
1.61 X 10^5										
2.11 X 10^5										
2.67 X 10^5										
3.16 X 10^5										
3.72 X 10^5										
4.28 X 10^5										
4.84 X 10^5										
5.33 X 10^5										
5.88 X 10^5										
6.38 X 10^5										
6.94 X 10^5									0/20	
7.72 X 10^5								0/20	1/20	0/20

WSTF Pressurized GOX Mechanical Impact Test Results

TABLE 9

MATERIAL : TEFLON TFE

Plummet Wt.: 3.4 kg

Striker Pin Dia.: 0.63 cm

Test Atmosphere: 100% O_2

Sample Dia.: 1.90 cm

Sample Thickness: 0.16 cm

NUMBER OF REACTIONS/NUMBER OF TESTS

ENERGY IMPACT - Joules per square meter	PRESSURE - Newton per square meter									
	13.6 X 10^4	68.0 X 10^4	1.7 X 10^6	3.4 X 10^6	6.8 X 10^6	10.3 X 10^6	13.6 X 10^6	20.6 X 10^6	27.2 X 10^6	34.0 X 10^6
1.07 X 10^5										
1.61 X 10^5										
2.11 X 10^5										
2.67 X 10^5										
3.16 X 10^5										
3.72 X 10^5										
4.28 X 10^5										
4.84 X 10^5										
5.33 X 10^5										
5.88 X 10^5										
6.38 X 10^5										
6.84 X 10^5										
7.72 X 10^5									0/20	0/20

WSTF Pressurized GOX Mechanical Impact Test Results

TABLE 10

MATERIAL : TEFLON TFE

Plummet Wt.: 3.4 kg

Striker Pin Dia.: 0.63 cm

Test Atmosphere: 100% O_2

Sample Dia.: 0.63 cm

Sample Thickness: 0.32 cm

NUMBER OF REACTIONS/NUMBER OF TESTS

ENERGY IMPACT - Joules per square meter	PRESSURE - Newton per square meter									
	13.6 X 10^4	68.0 X 10^4	1.7 X 10^6	3.4 X 10^6	6.8 X 10^6	10.3 X 10^6	13.6 X 10^6	20.6 X 10^6	27.2 X 10^6	34.0 X 10^6
1.07 X 10^5										
1.61 X 10^5										
2.11 X 10^5										
2.67 X 10^5										
3.16 X 10^5										
3.72 X 10^5										
4.28 X 10^5										
4.84 X 10^5										
5.33 X 10^5										
5.88 X 10^5										
6.38 X 10^5										
6.94 X 10^5										
7.72 X 10^5									0/20	0/20

WSTF Pressurized GOX Mechanical Impact Test Results

TABLE 11

MATERIAL: TEFLON TFE

Plummet Wt.: 3.4 kg

Striker Pin Dia.: 0.63 cm

Test Atmosphere: 100% O_2

Sample Dia.: 1.90 cm

Sample Thickness: 0.32 cm

NUMBER OF REACTIONS/NUMBER OF TESTS

ENERGY IMPACT - Joules per square meter	PRESSURE - Newton per square meter									
	13.6 X 10^4	68.0 X 10^4	1.7 X 10^6	3.4 X 10^6	6.8 X 10^6	10.3 X 10^6	13.6 X 10^6	20.6 X 10^6	27.2 X 10^6	34.0 X 10^6
1.07 X 10^5										
1.61 X 10^5										
2.11 X 10^5										
2.67 X 10^5										
3.16 X 10^5										
3.72 X 10^5										
4.28 X 10^5										
4.84 X 10^5										
5.33 X 10^5										
5.88 X 10^5										
6.38 X 10^5										
6.94 X 10^5										
7.72 X 10^5									0/20	0/20

WSTF Pressurized GOX Mechanical Impact Test Results

TABLE 12

MATERIAL: GARLOCK 8573

Plummet Wt.: 9.09 kg

Striker Pin Dia.: 1.27 cm

Test Atmosphere: 100% O_2

Sample Dia.: 1.90 cm

Sample Thickness: 0.16 cm

NUMBER OF REACTIONS/NUMBER OF TESTS

ENERGY IMPACT - Joules per square meter	PRESSURE - Newton per square meter									
	13.6 X 10^4	68.0 X 10^4	1.7 X 10^6	3.4 X 10^6	6.8 X 10^6	10.3 X 10^6	13.6 X 10^6	20.6 X 10^6	27.2 X 10^6	34.0 X 10^6
1.07 X 10^5										0/20
1.61 X 10^5										1/20
2.11 X 10^5										
2.67 X 10^5						0/20	0/5	0/20	0/20	1/18
3.16 X 10^5						0/5		1/20	5/20	
3.72 X 10^5						0/20				
4.28 X 10^5			0/5		0/5	1/20	0/5	1/8	1/1	1/1
4.84 X 10^5										
5.33 X 10^5										
5.88 X 10^5			0/5	0/5	0/20		0/20			
6.38 X 10^5					0/20		1/23			
6.94 X 10^5					0/20		1/16			
7.72 X 10^5	0/5	0/20	0/20	0/20	1/20		1/16			

WSTF Pressurized GOX Mechanical Impact Test Results

TABLE 13

MATERIAL: GARLOCK 8573

Plummet Wt.: 9.09 kg

Striker Pin Dia.: 1.27 cm

Test Atmosphere: 100% O_2

Sample Dia.: 1.90 cm

Sample Thickness: 0.32 cm

NUMBER OF REACTIONS/NUMBER OF TESTS

ENERGY IMPACT - Joules per square meter	PRESSURE - Newton per square meter									
	13.6 X 10^4	68.0 X 10^4	1.7 X 10^6	3.4 X 10^6	6.8 X 10^6	10.3 X 10^6	13.6 X 10^6	20.6 X 10^6	27.2 X 10^6	34.0 X 10^6
1.07 X 10^5										
1.61 X 10^5										
2.11 X 10^5										
2.67 X 10^5							0/20	0/20	0/20	0/20
3.16 X 10^5							0/20	0/20	0/20	0/20
3.72 X 10^5							2/20	1/20	1/23	2/20
4.28 X 10^5					0/5	0/5	1/21	1/1	1/2	0/20
4.84 X 10^5										1/1
5.33 X 10^5										
5.88 X 10^5					0/5	0/5	1/22			1/7
6.38 X 10^5										
6.94 X 10^5										1/4
7.72 X 10^5	0/7	0/20	0/20	0/20	0/20	0/20	1/6			

WSTF Pressurized GOX Mechanical Impact Test Results

TABLE 14

MATERIAL: FLUOROGREEN E600

Plummet Wt.: 9.09 kg **Sample Dia.:** 1.90 cm

Striker Pin Dia.: 1.27 cm **Sample Thickness:** 0.16 cm

Test Atmosphere: 100% O_2

NUMBER OF REACTIONS/NUMBER OF TESTS

ENERGY IMPACT - Joules per square meter	PRESSURE - Newton per square meter									
	13.6 X 10^4	68.0 X 10^4	1.7 X 10^6	3.4 X 10^6	6.8 X 10^6	10.3 X 10^6	13.6 X 10^6	20.6 X 10^6	27.2 X 10^6	34.0 X 10^6
1.07 X 10^5								0/5	0/5	0/5
1.61 X 10^5								0/20	0/5	0/5
2.11 X 10^5								3/20	0/20	0/20
2.67 X 10^5							0/5	1/2	5/20	6/20
3.16 X 10^5							0/5		1/2	
3.72 X 10^5							0/20	1/2		
4.28 X 10^5					0/5	0/20	1/20	0/5	1/1	
4.84 X 10^5					0/5	1/20	1/2	1/2		
5.33 X 10^5					0/20	1/12	1/1			
5.88 X 10^5					1/20	1/4	1/2	1/1		
6.38 X 10^5					1/20					
6.94 X 10^5										
7.72 X 10^5	0/5	0/20	0/20	0/20	1/3					

WSTF Pressurized GOX Mechanical Impact Test Results

TABLE 15

MATERIAL: FLUOROGREEN E600

Plummet Wt.: 9.09 kg

Striker Pin Dia.: 1.27 cm

Test Atmosphere: 100% O_2

Sample Dia.: 1.90 cm

Sample Thickness: 0.32 cm

NUMBER OF REACTIONS/NUMBER OF TESTS

ENERGY IMPACT - Joules per square meter	PRESSURE - Newton per square meter									
	13.6 X 10^4	68.0 X 10^4	1.7 X 10^6	3.4 X 10^6	6.8 X 10^6	10.3 X 10^6	13.6 X 10^6	20.6 X 10^6	27.2 X 10^6	34.0 X 10^6
1.07 X 10^5										
1.61 X 10^5										
2.11 X 10^5										
2.67 X 10^5								0/5	0/5	
3.16 X 10^5								0/20		
3.72 X 10^5								1/20		
4.28 X 10^5								1/17	0/5	0/20
4.84 X 10^5								1/4	0/20	2/20
5.33 X 10^5									5/20	1/5
5.88 X 10^5					0/5	0/5	0/5	1/1	1/8	1/8
6.38 X 10^5					0/5				1/16	1/1
6.94 X 10^5					0/20				1/2	
7.72 X 10^5	0/5	0/20	0/20	0/20	3/20	0/20	0/20		1/1	1/4

WSTF Pressurized GOX Mechanical Impact Test Results

TABLE 16

MATERIAL : RULON A

Plummet Wt.: 9.09 kg

Striker Pin Dia.: 1.27 cm

Test Atmosphere: 100% O_2

Sample Dia.: 1.90cm

Sample Thickness: 0.16 cm

NUMBER OF REACTIONS/NUMBER OF TESTS

ENERGY IMPACT - Joules per square meter	PRESSURE - Newton per square meter									
	13.6 X 10^4	68.0 X 10^4	1.7 X 10^6	3.4 X 10^6	6.8 X 10^6	10.3 X 10^6	13.6 X 10^6	20.6 X 10^6	27.2 X 10^6	34.0 X 10^6
1.07 X 10^5						0/20	0/20	0/20	0/5	0/5
1.61 X 10^5						0/20	0/20	0/20	0/20	0/20
2.11 X 10^5						0/20	1/20	4/20	1/20	3/20
2.67 X 10^5						5/20	3/20	3/5	1/1	1/2
3.16 X 10^5										
3.72 X 10^5										
4.28 X 10^5						1/5	1/3			
4.84 X 10^5										
5.33 X 10^5										
5.88 X 10^5						1/3				
6.38 X 10^5										
6.84 X 10^5										
7.72 X 10^5	0/5	0/20	0/20	0/20	0/20	1/1				

WSTF Pressurized GOX Mechanical Impact Test Results

TABLE 17

MATERIAL: RULON A

Plummet Wt.: 9.09 kg

Striker Pin Dia.: 1.27 cm

Test Atmosphere: 100% O_2

Sample Dia.: 1.90 cm

Sample Thickness: 0.32 cm

NUMBER OF REACTIONS/NUMBER OF TESTS

ENERGY IMPACT - Joules per square meter	PRESSURE - Newton per square meter									
	13.6 X 10^4	68.0 X 10^4	1.7 X 10^6	3.4 X 10^6	6.8 X 10^6	10.3 X 10^6	13.6 X 10^6	20.6 X 10^6	27.2 X 10^6	34.0 X 10^6
1.07 X 10^5										0/5
1.61 X 10^5										0/20
2.11 X 10^5										0/20
2.67 X 10^5										1/20
3.16 X 10^5										
3.72 X 10^5										
4.28 X 10^5						0/20		0/20	0/20	1/15
4.84 X 10^5						1/20		2/20	1/20	
5.33 X 10^5										
5.88 X 10^5						1/9	0/5	1/11	1/3	1/1
6.38 X 10^5						1/7	0/20	4/12		
6.94 X 10^5							0/20			
7.72 X 10^5	0/5	0/20	0/20	0/20	0/20	1/9	3/20	1/2		

WSTF Pressurized GOX Mechanical Impact Test Results

TABLE 18

MATERIAL: FLUOROGOLD

Plummet Wt.: 9.09 kg

Striker Pin Dia.: 1.27 cm

Test Atmosphere: 100% O_2

Sample Dia.: 1.90 cm

Sample Thickness: 0.16 cm

NUMBER OF REACTIONS/NUMBER OF TESTS

ENERGY IMPACT - Joules per square meter	PRESSURE - Newton per square meter									
	13.6 X 10^4	68.0 X 10^4	1.7 X 10^6	3.4 X 10^6	6.8 X 10^6	10.3 X 10^6	13.6 X 10^6	20.6 X 10^6	27.2 X 10^6	34.0 X 10^6
1.07 X 10^5								0/20	1/20	1/20
1.61 X 10^5								0/20		
2.11 X 10^5								3/20		
2.67 X 10^5								1/1	1/4	
3.16 X 10^5										
3.72 X 10^5										
4.28 X 10^5							0/20	1/2		
4.84 X 10^5							7/20			
5.33 X 10^5							1/12			
5.88 X 10^5			0/5	0/5	0/5	0/20	1/4			
6.38 X 10^5						2/20				
6.94 X 10^5						1/14				
7.72 X 10^5	0/20	0/20	0/20	0/20	0/20	1/14				

WSTF Pressurized GOX Mechanical Impact Test Results

TABLE 19

MATERIAL : FLUOROGOLD

Plummet Wt.: 9.09 kg

Striker Pin Dia.: 1.27 cm

Test Atmosphere: 100% O_2

Sample Dia.: 1.90 cm

Sample Thickness: 0.32 cm

NUMBER OF REACTIONS/NUMBER OF TESTS

ENERGY IMPACT - Joules per square meter	PRESSURE - Newton per square meter									
	13.6 X 10^4	68.0 X 10^4	1.7 X 10^6	3.4 X 10^6	6.8 X 10^6	10.3 X 10^6	13.6 X 10^6	20.6 X 10^6	27.2 X 10^6	34.0 X 10^6
1.07 X 10^5									0/20	
1.61 X 10^5										
2.11 X 10^5									0/20	
2.67 X 10^5								0/20	1/20	0/20
3.16 X 10^5								0/20		0/20
3.72 X 10^5								1/20		4/20
4.28 X 10^5								1/7		1/2
4.84 X 10^5										
5.33 X 10^5										
5.88 X 10^5			0/5	0/5	0/5	0/20	0/20	1/7		
6.38 X 10^5							0/20			
6.84 X 10^5						0/20	3/20			
7.72 X 10^5	0/20	0/20	0/20	0/20	0/20	1/20	1/9			

WSTF Pressurized GOX Mechanical Impact Test Results

TABLE 20

MATERIAL: KEL-F

Plummet Wt.: 9.09 kg

Striker Pin Dia.: 1.27 cm

Test Atmosphere: 100% O_2

Sample Dia.: 1.90 cm

Sample Thickness: 0.16 cm

NUMBER OF REACTIONS/NUMBER OF TESTS

ENERGY IMPACT - Joules per square meter	PRESSURE - Newton per square meter									
	13.6 X 10^4	68.0 X 10^4	1.7 X 10^6	3.4 X 10^6	6.8 X 10^6	10.3 X 10^6	13.6 X 10^6	20.6 X 10^6	27.2 X 10^6	34.0 X 10^6
1.07 X 10^5										
1.61 X 10^5										
2.11 X 10^5										
2.67 X 10^5										
3.16 X 10^5										
3.72 X 10^5										
4.28 X 10^5						0/20	0/20	0/20	0/20	0/20
4.84 X 10^5						0/20	1/20	0/20	1/20	1/20
5.33 X 10^5						2/20	1/1	1/20	1/2	
5.88 X 10^5				0/5	0/5	1/16	3/20	4/20	1/2	1/6
6.38 X 10^5										
6.94 X 10^5										
7.72 X 10^5	0/5	0/20	0/20	0/20	0/20	1/5				

WSTF Pressurized GOX Mechanical Impact Test Results

TABLE 21

MATERIAL: KEL-F

Plummet Wt.: 9.09 kg

Striker Pin Dia.: 1.27 cm

Test Atmosphere: 100% O_2

Sample Dia.: 1.90 cm

Sample Thickness: 0.32 cm

NUMBER OF REACTIONS/NUMBER OF TESTS

ENERGY IMPACT - Joules per square meter	PRESSURE - Newton per square meter									
	13.6 X 10^4	68.0 X 10^4	1.7 X 10^6	3.4 X 10^6	6.8 X 10^6	10.3 X 10^6	13.6 X 10^6	20.6 X 10^6	27.2 X 10^6	34.0 X 10^6
1.07 X 10^5										
1.61 X 10^5										
2.11 X 10^5										
2.67 X 10^5										
3.16 X 10^5										
3.72 X 10^5										
4.28 X 10^5								0/20		
4.84 X 10^5										
5.33 X 10^5								0/20		
5.88 X 10^5			0/5	0/5	0/20	0/5	0/20	1/20	0/20	0/20
6.38 X 10^5									1/20	0/20
6.94 X 10^5					0/20		0/20		1/2	2/20
7.72 X 10^5	0/20	0/20	0/20	0/20	2/20	0/20	1/2	1/10	1/2	1/4

WSTF Pressurized GOX Mechanical Impact Test Results

TABLE 22

MATERIAL: VESPEL SP-21

Plummet Wt.: 9.09 kg

Striker Pin Dia.: 1.27 cm

Test Atmosphere: 100% O_2

Sample Dia.: 2.22 cm

Sample Thickness: 0.16 cm

NUMBER OF REACTIONS/NUMBER OF TESTS

ENERGY IMPACT - Joules per square meter	PRESSURE - Newton per square meter									
	13.6 X 10^4	68.0 X 10^4	1.7 X 10^6	3.4 X 10^6	6.8 X 10^6	10.3 X 10^6	13.6 X 10^6	20.6 X 10^6	27.2 X 10^6	34.0 X 10^6
1.07 X 10^5							0/20	0/20	0/20	0/20
1.61 X 10^5									4/20	3/20
2.11 X 10^5							0/20	0/20	1/1	
2.67 X 10^5							2/20	1/20	1/4	1/11
3.16 X 10^5										
3.72 X 10^5										
4.28 X 10^5		0/20				0/20	1/3			1/1
4.84 X 10^5										
5.33 X 10^5		0/20				0/20				
5.88 X 10^5		1/20	0/20	0/20	0/20	1/20	1/1			
6.38 X 10^5			0/20	1/20	0/20					
6.94 X 10^5			0/20	1/5	5/20					
7.72 X 10^5	0/20	1/11	1/20	1/4	1/9					

WSTF Pressurized GOX Mechanical Impact Test Results

TABLE 23

MATERIAL: VESPEL SP-21

Plummet Wt.: 9.09 kg **Sample Dia.:** 2.22cm

Striker Pin Dia.: 1.27 cm **Sample Thickness:** 0.32 cm

Test Atmosphere: 100% O_2

NUMBER OF REACTIONS/NUMBER OF TESTS

ENERGY IMPACT - Joules per square meter	PRESSURE - Newton per square meter									
	13.6 X 10^4	68.0 X 10^4	1.7 X 10^6	3.4 X 10^6	6.8 X 10^6	10.3 X 10^6	13.6 X 10^6	20.6 X 10^6	27.2 X 10^6	34.0 X 10^6
1.07 X 10^5									0/20	
1.61 X 10^5									0/20	
2.11 X 10^5									2/20	
2.67 X 10^5									1/2	0/20
3.16 X 10^5										6/20
3.72 X 10^5										
4.28 X 10^5									1/4	1/1
4.84 X 10^5										
5.33 X 10^5										
5.88 X 10^5		0/5	0/5	0/5	0/5	0/5	0/5	0/5	1/5	
6.38 X 10^5										
6.94 X 10^5								0/20		
7.72 X 10^5	0/20	0/20	0/20	0/20	0/20	0/20	0/20	1/20		

WSTF Pressurized GOX Mechanical Impact Test Results

TABLE 24

MATERIAL: VESPEL SP-21

Plummet Wt.: 3.4 kg

Striker Pin Dia.: 0.63 cm

Test Atmosphere: 100% O_2

Sample Dia.: 0.63 cm

Sample Thickness: 0.16 cm

NUMBER OF REACTIONS/NUMBER OF TESTS

ENERGY IMPACT - Joules per square meter	PRESSURE - Newton per square meter									
	13.6 X 10^4	68.0 X 10^4	1.7 X 10^6	3.4 X 10^6	6.8 X 10^6	10.3 X 10^6	13.6 X 10^6	20.6 X 10^6	27.2 X 10^6	34.0 X 10^6
1.07 X 10^5										0/20 0/5
1.61 X 10^5										0/20
2.11 X 10^5										1/20
2.67 X 10^5										1/1 0/5
3.16 X 10^5										
3.72 X 10^5										
4.28 X 10^5										2/2 0/5
4.84 X 10^5										
5.33 X 10^5										
5.88 X 10^5										0/5
6.38 X 10^5										
6.94 X 10^5										
7.72 X 10^5										0/20

WSTF Pressurized GOX Mechanical Impact Test Results

TABLE 25

MATERIAL : VESPEL SP-21

Plummet Wt.: 3.4 kg

Striker Pin Dia.: 0.63 cm

Test Atmosphere: 100% O_2

Sample Dia.: 2.22 cm

Sample Thickness: 0.16 cm

NUMBER OF REACTIONS/NUMBER OF TESTS

ENERGY IMPACT - Joules per square meter	PRESSURE - Newton per square meter									
	13.6 X 10^4	68.0 X 10^4	1.7 X 10^6	3.4 X 10^6	6.8 X 10^6	10.3 X 10^6	13.6 X 10^6	20.6 X 10^6	27.2 X 10^6	34.0 X 10^6
1.07 X 10^5										
1.61 X 10^5										
2.11 X 10^5										
2.67 X 10^5										0/20
3.16 X 10^5										0/20
3.72 X 10^5										1/20
4.28 X 10^5										1/12
4.84 X 10^5										
5.33 X 10^5										
5.88 X 10^5										1/8
6.38 X 10^5										
6.94 X 10^5										
7.72 X 10^5										1/14

WSTF Pressurized GOX Mechanical Impact Test Results

TABLE 26

MATERIAL: VESPEL SP-21

Plummet Wt.: 3.4 kg

Striker Pin Dia.: 0.63 cm

Test Atmosphere: 100% O_2

Sample Dia.: 0.63 cm

Sample Thickness: 0.32 cm

NUMBER OF REACTIONS/NUMBER OF TESTS

ENERGY IMPACT - Joules per square meter	PRESSURE - Newton per square meter									
	13.6 X 10^4	68.0 X 10^4	1.7 X 10^6	3.4 X 10^6	6.8 X 10^6	10.3 X 10^6	13.6 X 10^6	20.6 X 10^6	27.2 X 10^6	34.0 X 10^6
1.07 X 10^5										0/5
1.61 X 10^5										
2.11 X 10^5										
2.67 X 10^5										0/5
3.16 X 10^5										
3.72 X 10^5										
4.28 X 10^5										0/20 0/5
4.84 X 10^5										0/20
5.33 X 10^5										0/20
5.88 X 10^5										2/20 0/5
6.38 X 10^5										
6.94 X 10^5										
7.72 X 10^5										0/20

WSTF Pressurized GOX Mechanical Impact Test Results

TABLE 27

MATERIAL: VESPEL SP-21

Plummet Wt.: 3.4 kg

Striker Pin Dia.: 0.63 cm

Test Atmosphere: 100% O_2

Sample Dia.: 2.22 cm

Sample Thickness: 0.32 cm

NUMBER OF REACTIONS/NUMBER OF TESTS

ENERGY IMPACT - Joules per square meter	PRESSURE - Newton per square meter									
	13.6×10^4	68.0×10^4	1.7×10^6	3.4×10^6	6.8×10^6	10.3×10^6	13.6×10^6	20.6×10^6	27.2×10^6	34.0×10^6
1.07×10^5										
1.61×10^5										
2.11×10^5										
2.67×10^5										
3.16×10^5										
3.72×10^5										
4.28×10^5										0/20
4.84×10^5										3/20
5.33×10^5										
5.88×10^5										1/5
6.38×10^5										
6.84×10^5										
7.72×10^5										

WSTF Pressurized GOX Mechanical Impact Test Results

TABLE 28

MATERIAL: NYLON 6/6 ALLOY

Plummet Wt.: 9.09 kg **Sample Dia.:** 1.90 cm

Striker Pin Dia.: 1.27 cm **Sample Thickness:** 0.16 cm

Test Atmosphere: 100% O_2

NUMBER OF REACTIONS/NUMBER OF TESTS

ENERGY IMPACT - Joules per square meter	PRESSURE - Newton per square meter									
	13.6 X 10^4	68.0 X 10^4	1.7 X 10^6	3.4 X 10^6	6.8 X 10^6	10.3 X 10^6	13.6 X 10^6	20.6 X 10^6	27.2 X 10^6	34.0 X 10^6
1.07 X 10^5								0/20	0/5	0/20
1.61 X 10^5								0/20		0/20
2.11 X 10^5								0/20		0/20
2.67 X 10^5								1/20	0/20	1/20
3.16 X 10^5									0/20	
3.72 X 10^5									0/20	
4.28 X 10^5				0/20				1/1	3/20	1/4
4.84 X 10^5				0/8						
5.33 X 10^5				0/20						
5.88 X 10^5				1/25	0/5	0/5	0/5			1/7
6.38 X 10^5										
6.94 X 10^5										
7.72 X 10^5	0/5	0/20	0/20	0/20 1/28	10/20 0/20	0/20	0/20			1/7

WSTF Pressurized GOX Mechanical Impact Test Results

TABLE 29

MATERIAL: NYLON 6/6 ALLOY

Plummet Wt.: 9.09 kg **Sample Dia.:** 1.90 cm

Striker Pin Dia.: 1.27 cm **Sample Thickness:** 0.32 cm

Test Atmosphere: 100% O_2

NUMBER OF REACTIONS/NUMBER OF TESTS

ENERGY IMPACT - Joules per square meter	PRESSURE - Newton per square meter									
	13.6×10^4	68.0×10^4	1.7×10^6	3.4×10^6	6.8×10^6	10.3×10^6	13.6×10^6	20.6×10^6	27.2×10^6	34.0×10^6
1.07×10^5								0/20	0/20	
1.61×10^5								1/20	0/20	
2.11×10^5									0/20	
2.67×10^5					0/20			1/11	1/20	
3.16×10^5										
3.72×10^5					0/20					
4.28×10^5					1/20			1/2	1/8	
4.84×10^5										
5.33×10^5										
5.88×10^5			0/20	0/20	1/8	0/20	0/5		1/3	0/20
6.38×10^5										3/20
6.94×10^5			0/20	0/20		0/20				1/4
7.72×10^5	0/5	0/20	3/20	1/20	1/16	3/20	0/40			1/6

WSTF Pressurized GOX Mechanical Impact Test Results

TABLE 30

MATERIAL: NYLON 6/6 ALLOY

Plummet Wt.: 3.4 kg

Striker Pin Dia.: 0.63 cm

Test Atmosphere: 100% O_2

Sample Dia.: 0.63 cm

Sample Thickness: 0.16 cm

NUMBER OF REACTIONS/NUMBER OF TESTS

ENERGY IMPACT - Joules per square meter	PRESSURE - Newton per square meter									
	13.6 X 10^4	68.0 X 10^4	1.7 X 10^6	3.4 X 10^6	6.8 X 10^6	10.3 X 10^6	13.6 X 10^6	20.6 X 10^6	27.2 X 10^6	34.0 X 10^6
1.07 X 10^5								0/5 0/5	0/5	0/5
1.61 X 10^5										
2.11 X 10^5										
2.67 X 10^5								0/20 0/20	0/5	0/5
3.16 X 10^5								1/20 0/20		
3.72 X 10^5								0/20		
4.28 X 10^5								1/19 2/20	0/20	0/20
4.84 X 10^5									3/20	1/20
5.33 X 10^5										
5.88 X 10^5								1/2 1/7	1/2	1/7
6.38 X 10^5										
6.94 X 10^5										
7.72 X 10^5								1/1		1/1

WSTF Pressurized GOX Mechanical Impact Test Results

TABLE 31

MATERIAL: NYLON 6/6 ALLOY

Plummet Wt.: 3.4 kg **Sample Dia.:** 1.90 cm

Striker Pin Dia.: 0.63 cm **Sample Thickness:** 0.16 cm

Test Atmosphere: 100% O_2

NUMBER OF REACTIONS/NUMBER OF TESTS

ENERGY IMPACT - Joules per square meter	PRESSURE - Newton per square meter									
	13.6 X 10^4	68.0 X 10^4	1.7 X 10^6	3.4 X 10^6	6.8 X 10^6	10.3 X 10^6	13.6 X 10^6	20.6 X 10^6	27.2 X 10^6	34.0 X 10^6
1.07 X 10^5								0/5	0/5	
1.61 X 10^5										
2.11 X 10^5										
2.67 X 10^5								0/5	0/5	
3.16 X 10^5										
3.72 X 10^5										
4.28 X 10^5								0/20	0/20	
4.84 X 10^5								4/20	0/20	
5.33 X 10^5									3/20	
5.88 X 10^5								1/5	1/17	
6.38 X 10^5										
6.84 X 10^5										
7.72 X 10^5									1/2	

WSTF Pressurized GOX Mechanical Impact Test Results

TABLE 32

MATERIAL: NYLON 6/6 ALLOY

Plummet Wt.: 3.4 kg

Striker Pin Dia.: 0.63 cm

Test Atmosphere: 100% O_2

Sample Dia.: 0.63 cm

Sample Thickness: 0.32 cm

NUMBER OF REACTIONS/NUMBER OF TESTS

ENERGY IMPACT - Joules per square meter	PRESSURE - Newton per square meter									
	13.6 X 10^4	68.0 X 10^4	1.7 X 10^6	3.4 X 10^6	6.8 X 10^6	10.3 X 10^6	13.6 X 10^6	20.6 X 10^6	27.2 X 10^6	34.0 X 10^6
1.07 X 10^5								0/5	0/5	
1.61 X 10^5										
2.11 X 10^5										
2.67 X 10^5								0/5	0/5	0/20
3.16 X 10^5										0/20
3.72 X 10^5										0/20
4.28 X 10^5								0/6 0/5	0/5 0/5	1/20
4.84 X 10^5										
5.33 X 10^5										
5.88 X 10^5								0/20 0/5	0/5 0/5	
6.38 X 10^5								1/20		
6.84 X 10^5										
7.72 X 10^5								1/16 0/20	0/20 0/5	

WSTF Pressurized GOX Mechanical Impact Test Results

TABLE 33

MATERIAL : NYLON 6/6 ALLOY

Plummet Wt.: 3.4 kg

Striker Pin Dia.: 0.63 cm

Test Atmosphere: 100% O_2

Sample Dia.: 1.90 cm

Sample Thickness: 0.32 cm

NUMBER OF REACTIONS/NUMBER OF TESTS

ENERGY IMPACT - Joules per square meter	PRESSURE - Newton per square meter									
	13.6 X 10^4	68.0 X 10^4	1.7 X 10^6	3.4 X 10^6	6.8 X 10^6	10.3 X 10^6	13.6 X 10^6	20.6 X 10^6	27.2 X 10^6	34.0 X 10^6
1.07 X 10^5								0/5	0/5	
1.61 X 10^5										
2.11 X 10^5										
2.67 X 10^5								0/5	0/20	
3.16 X 10^5									0/20	
3.72 X 10^5									0/20	
4.28 X 10^5								0/5	1/20	
4.84 X 10^5										
5.33 X 10^5										
5.88 X 10^5								0/5		
6.38 X 10^5										
6.94 X 10^5										
7.72 X 10^5								0/20		

WSTF Pressurized GOX Mechanical Impact Test Results

TABLE 34

MATERIAL: VITON 5010B

Plummet Wt.: 9.09 kg

Striker Pin Dia.: 1.27 cm

Test Atmosphere: 100% O_2

Sample Dia.: 1.90 cm

Sample Thickness: 0.16 cm

NUMBER OF REACTIONS/NUMBER OF TESTS

ENERGY IMPACT - Joules per square meter	PRESSURE - Newton per square meter									
	13.6 X 10^4	68.0 X 10^4	1.7 X 10^6	3.4 X 10^6	6.8 X 10^6	10.3 X 10^6	13.6 X 10^6	20.6 X 10^6	27.2 X 10^6	34.0 X 10^6
1.07 X 10^5										
1.61 X 10^5										
2.11 X 10^5										
2.67 X 10^5								0/20	0/20	
3.16 X 10^5								0/20		
3.72 X 10^5								1/20	0/20	
4.28 X 10^5				0/20	0/20	0/20	0/20	1/15	1/20	0/30
4.84 X 10^5					0/20	1/20	0/20			
5.33 X 10^5				0/20	1/20	1/3	4/20			
5.88 X 10^5		0/5	0/5	1/20	1/8	1/4	6/20	1/4		2/30
6.38 X 10^5										9/20
6.94 X 10^5										
7.72 X 10^5	0/5	0/20	0/20	1/19						1/1

WSTF Pressurized GOX Mechanical Impact Test Results

TABLE 35

MATERIAL: VITON 5010B

Plummet Wt.: 9.09 kg

Striker Pin Dia.: 1.27 cm

Test Atmosphere: 100% O_2

Sample Dia.: 1.90 cm

Sample Thickness: 0.32 cm

NUMBER OF REACTIONS/NUMBER OF TESTS

ENERGY IMPACT - Joules per square meter	PRESSURE - Newton per square meter									
	13.6 X 10^4	68.0 X 10^4	1.7 X 10^6	3.4 X 10^6	6.8 X 10^6	10.3 X 10^6	13.6 X 10^6	20.6 X 10^6	27.2 X 10^6	34.0 X 10^6
1.07 X 10^5										
1.61 X 10^5										
2.11 X 10^5										
2.67 X 10^5										
3.16 X 10^5										
3.72 X 10^5										
4.28 X 10^5					0/20	0/20	0/20	0/20	0/20	0/20
4.84 X 10^5					0/20		0/20	0/20	0/20	
5.33 X 10^5					2/20	0/20	1/20	3/20	0/20	0/20
5.88 X 10^5				0/5	1/3	1/20	1/12	1/4	4/20	6/20
6.38 X 10^5										
6.84 X 10^5										
7.72 X 10^5	0/20	0/20	0/20	0/20						1/1

WSTF Pressurized GOX Mechanical Impact Test Results

TABLE 36

MATERIAL: VITON 5010B

Plummet Wt.: 3.4 kg

Striker Pin Dia.: 0.63 cm

Test Atmosphere: 100% O_2

Sample Dia.: 0.63 cm

Sample Thickness: 0.16 cm

NUMBER OF REACTIONS/NUMBER OF TESTS

ENERGY IMPACT - Joules per square meter	PRESSURE - Newton per square meter									
	13.6 X 10^4	68.0 X 10^4	1.7 X 10^6	3.4 X 10^6	6.8 X 10^6	10.3 X 10^6	13.6 X 10^6	20.6 X 10^6	27.2 X 10^6	34.0 X 10^6
1.07 X 10^5										
1.61 X 10^5										
2.11 X 10^5										
2.67 X 10^5										
3.16 X 10^5										
3.72 X 10^5										
4.28 X 10^5								0/20		
4.84 X 10^5								0/20		
5.33 X 10^5								0/20		
5.88 X 10^5								1/20		
6.38 X 10^5										
6.94 X 10^5										
7.72 X 10^5								1/20	1/13	

WSTF Pressurized GOX Mechanical Impact Test Results

TABLE 37

MATERIAL: VITON 5010B

Plummet Wt.: 3.4 kg

Striker Pin Dia.: 0.63cm

Test Atmosphere: 100% O_2

Sample Dia.: 1.90 cm

Sample Thickness: 0.16 cm

NUMBER OF REACTIONS/NUMBER OF TESTS

ENERGY IMPACT - Joules per square meter	PRESSURE - Newton per square meter									
	13.6 X 10^4	68.0 X 10^4	1.7 X 10^6	3.4 X 10^6	6.8 X 10^6	10.3 X 10^6	13.6 X 10^6	20.6 X 10^6	27.2 X 10^6	34.0 X 10^6
1.07 X 10^5										
1.61 X 10^5										
2.11 X 10^5										
2.67 X 10^5										
3.16 X 10^5										
3.72 X 10^5										
4.28 X 10^5								0/5	0/20	
4.84 X 10^5									0/20	
5.33 X 10^5									0/20	
5.88 X 10^5								0/5	1/20	
6.38 X 10^5										
6.94 X 10^5										
7.72 X 10^5								0/5	1/5	

WSTF Pressurized GOX Mechanical Impact Test Results

TABLE 38

MATERIAL: VITON 5010B

Plummet Wt.: 3.4 kg

Striker Pin Dia.: 0.63 cm

Test Atmosphere: 100% O_2

Sample Dia.: 0.63 cm

Sample Thickness: 0.32 cm

NUMBER OF REACTIONS/NUMBER OF TESTS

ENERGY IMPACT - Joules per square meter	PRESSURE - Newton per square meter									
	13.6 X 10^4	68.0 X 10^4	1.7 X 10^6	3.4 X 10^6	6.8 X 10^6	10.3 X 10^6	13.6 X 10^6	20.6 X 10^6	27.2 X 10^6	34.0 X 10^6
1.07 X 10^5										
1.61 X 10^5										
2.11 X 10^5										
2.67 X 10^5										
3.16 X 10^5										
3.72 X 10^5										
4.28 X 10^5										
4.84 X 10^5										
5.33 X 10^5										
5.88 X 10^5								0/5		0/20
6.38 X 10^5										0/20
6.84 X 10^5										0/20
7.72 X 10^5								0/20	0/20	1/20

WSTF Pressurized GOX Mechanical Impact Test Results

TABLE 39

MATERIAL: VITON 5010B

Plummet Wt.: 3.4 kg

Striker Pin Dia.: 0.63 cm

Test Atmosphere: 100% O_2

Sample Dia.: 1.90 cm

Sample Thickness: 0.32 cm

NUMBER OF REACTIONS/NUMBER OF TESTS

ENERGY IMPACT - Joules per square meter	PRESSURE - Newton per square meter									
	13.6×10^4	68.0×10^4	1.7×10^6	3.4×10^6	6.8×10^6	10.3×10^6	13.6×10^6	20.6×10^6	27.2×10^6	34.0×10^6
1.07×10^5										
1.61×10^5										
2.11×10^5										
2.67×10^5										
3.16×10^5										
3.72×10^5										
4.28×10^5								0/5		
4.84×10^5										
5.33×10^5										
5.88×10^5								0/20		
6.38×10^5								0/20		
6.94×10^5								0/20		
7.72×10^5								2/20		

WSTF Pressurized GOX Mechanical Impact Test Results

TABLE 40

MATERIAL: FLUOREL E2160

Plummet Wt.: 9.09 kg **Sample Dia.:** 1.90 cm

Striker Pin Dia.: 1.27 cm **Sample Thickness:** 0.16 cm

Test Atmosphere: 100% O_2

NUMBER OF REACTIONS/NUMBER OF TESTS

ENERGY IMPACT - Joules per square meter	PRESSURE - Newton per square meter									
	13.6 X 10^4	68.0 X 10^4	1.7 X 10^6	3.4 X 10^6	6.8 X 10^6	10.3 X 10^6	13.6 X 10^6	20.6 X 10^6	27.2 X 10^6	34.0 X 10^6
1.07 X 10^5								0/5		
1.61 X 10^5										
2.11 X 10^5										
2.67 X 10^5						0/5	0/20	0/5	0/20	0/20
3.16 X 10^5						0/20	1/20		1/20	2/20
3.72 X 10^5						1/20	1/10		1/6	1/1
4.28 X 10^5				0/5		1/1	1/1	0/20	1/1	
4.84 X 10^5				0/5				1/20		
5.33 X 10^5				0/20						
5.88 X 10^5				2/20	0/20	1/7		1/4		
6.38 X 10^5					1/20	1/2				
6.94 X 10^5					1/9	1/7				
7.72 X 10^5		0/20 0/20	1/20 0/20	1/18 1/3	2/20 1/4	1/1 1/5	1/1			

WSTF Pressurized GOX Mechanical Impact Test Results

TABLE 41

MATERIAL: FLUOREL E2160

Plummet Wt.: 9.09 kg **Sample Dia.:** 1.90 cm

Striker Pin Dia.: 1.27 cm **Sample Thickness:** 0.32 cm

Test Atmosphere: 100% O_2

NUMBER OF REACTIONS/NUMBER OF TESTS

ENERGY IMPACT - Joules per square meter	PRESSURE - Newton per square meter									
	13.6 X 10^4	68.0 X 10^4	1.7 X 10^6	3.4 X 10^6	6.8 X 10^6	10.3 X 10^6	13.6 X 10^6	20.6 X 10^6	27.2 X 10^6	34.0 X 10^6
1.07 X 10^5								0/5		
1.61 X 10^5										
2.11 X 10^5										
2.67 X 10^5								0/5		
3.16 X 10^5										
3.72 X 10^5										
4.28 X 10^5				0/5	0/5	0/5	0/5	0/5	0/20	0/20
4.84 X 10^5				0/5	0/20	0/20	0/20		2/20	3/20
5.33 X 10^5				1/20	1/20	1/20	2/20		1/1	1/6
5.88 X 10^5				1/20	1/1	1/5	1/5	0/20		1/1
6.38 X 10^5				1/1				0/20		
6.84 X 10^5								2/20		
7.72 X 10^5	0/5	0/5	0/20	1/9				1/5		

WSTF Pressurized GOX Mechanical Impact Test Results

TABLE 42

MATERIAL: FLUOREL E2160

Plummet Wt.: 3.4 kg

Striker Pin Dia.: 0.63 cm

Test Atmosphere: 100% O_2

Sample Dia.: 0.63 cm

Sample Thickness: 0.16 cm

NUMBER OF REACTIONS/NUMBER OF TESTS

ENERGY IMPACT - Joules per square meter	PRESSURE - Newton per square meter									
	13.6 X 10^4	68.0 X 10^4	1.7 X 10^6	3.4 X 10^6	6.8 X 10^6	10.3 X 10^6	13.6 X 10^6	20.6 X 10^6	27.2 X 10^6	34.0 X 10^6
1.07 X 10^5								0/5	0/20	
1.61 X 10^5										
2.11 X 10^5										
2.67 X 10^5								0/20 0/20	0/20	
3.16 X 10^5								0/20 0/20		
3.72 X 10^5								0/20 3/20		
4.28 X 10^5								1/5 3/20	0/20	0/20
4.84 X 10^5										3/20
5.33 X 10^5									0/20	1/5
5.88 X 10^5								1/6	5/20	1/6
6.38 X 10^5								0/1		
6.84 X 10^5								5/20		
7.72 X 10^5							0/1	1/1	1/1	1/11

WSTF Pressurized GOX Mechanical Impact Test Results

TABLE 43

MATERIAL : FLUOREL E2160

Plummet Wt.: 3.4 kg **Sample Dia.:** 1.90 cm

Striker Pin Dia.: 0.63 cm **Sample Thickness:** 0.16 cm

Test Atmosphere: 100% O_2

NUMBER OF REACTIONS/NUMBER OF TESTS

ENERGY IMPACT - Joules per square meter	PRESSURE - Newton per square meter									
	13.6×10^4	68.0×10^4	1.7×10^6	3.4×10^6	6.8×10^6	10.3×10^6	13.6×10^6	20.6×10^6	27.2×10^6	34.0×10^6
1.07×10^5								0/20		
1.61×10^5								0/20		
2.11×10^5								1/20		
2.67×10^5								1/13		
3.16×10^5										
3.72×10^5										
4.28×10^5								1/8		
4.84×10^5										
5.33×10^5										
5.88×10^5								1/2		
6.38×10^5										
6.94×10^5										
7.72×10^5										

WSTF Pressurized GOX Mechanical Impact Test Results

TABLE 44

MATERIAL: FLUOREL E2160

Plummet Wt.: 3.4 kg

Striker Pin Dia.: 0.63 cm

Test Atmosphere: 100% O_2

Sample Dia.: 0.63 cm

Sample Thickness: 0.32 cm

NUMBER OF REACTIONS/NUMBER OF TESTS

ENERGY IMPACT - Joules per square meter	PRESSURE - Newton per square meter									
	13.6 X 10^4	68.0 X 10^4	1.7 X 10^6	3.4 X 10^6	6.8 X 10^6	10.3 X 10^6	13.6 X 10^6	20.6 X 10^6	27.2 X 10^6	34.0 X 10^6
1.07 X 10^5								0/5		0/2
1.61 X 10^5										
2.11 X 10^5										
2.67 X 10^5								0/5 0/5	0/5	0/2
3.16 X 10^5										
3.72 X 10^5										
4.28 X 10^5							0/5	0/5 0/5	0/5	0/2
4.84 X 10^5										
5.33 X 10^5										
5.88 X 10^5							0/5	0/5 0/20	0/5	0/20
6.38 X 10^5								0/20		0/20
6.84 X 10^5								0/20		0/20
7.72 X 10^5							0/5	0/20 1/20	0/20	1/20

WSTF Pressurized GOX Mechanical Impact Test Results

TABLE 45

MATERIAL : FLUOREL E2160

Plummet Wt.: 3.4 kg

Striker Pin Dia.: 0.63 cm

Test Atmosphere: 100% O_2

Sample Dia.: 1.90 cm

Sample Thickness: 0.32 cm

NUMBER OF REACTIONS/NUMBER OF TESTS

ENERGY IMPACT - Joules per square meter	PRESSURE - Newton per square meter									
	13.6 X 10^4	68.0 X 10^4	1.7 X 10^6	3.4 X 10^6	6.8 X 10^6	10.3 X 10^6	13.6 X 10^6	20.6 X 10^6	27.2 X 10^6	34.0 X 10^6
1.07 X 10^5								0/5		
1.61 X 10^5										
2.11 X 10^5										
2.67 X 10^5								0/5		
3.16 X 10^5										
3.72 X 10^5										
4.28 X 10^5								0/20		
4.84 X 10^5								1/20		
5.33 X 10^5										
5.88 X 10^5								1/2		
6.38 X 10^5										
6.94 X 10^5										
7.72 X 10^5										

WSTF Pressurized GOX Mechanical Impact Test Results

TABLE 46

MATERIAL: ALUMINUM 6061-T6

Plummet Wt.: 9.09 kg

Striker Pin Dia.: 1.27 cm

Test Atmosphere: 100% O_2

Sample Dia.: 1.90 cm

Sample Thickness: 0.16 cm

NUMBER OF REACTIONS/NUMBER OF TESTS

ENERGY IMPACT - Joules per square meter	PRESSURE - Newton per square meter									
	13.6 X 10^4	68.0 X 10^4	1.7 X 10^6	3.4 X 10^6	6.8 X 10^6	10.3 X 10^6	13.6 X 10^6	20.6 X 10^6	27.2 X 10^6	34.0 X 10^6
1.07 X 10^5										
1.61 X 10^5										
2.11 X 10^5										
2.67 X 10^5										
3.16 X 10^5										
3.72 X 10^5										
4.28 X 10^5										
4.84 X 10^5										
5.33 X 10^5										
5.88 X 10^5							0/5			
6.38 X 10^5							0/5			
6.84 X 10^5							0/20			
7.72 X 10^5	0/5	0/20	0/20	0/20	0/20	0/20	1/20			

WSTF Pressurized GOX Mechanical Impact Test Results

TABLE 47

MATERIAL: ALUMINUM 6061-T6

Plummet Wt.: 9.09 kg

Sample Dia.: 1.90 cm

Striker Pin Dia.: 1.27 cm

Sample Thickness: 0.32 cm

Test Atmosphere: 100% O_2

NUMBER OF REACTIONS/NUMBER OF TESTS

ENERGY IMPACT - Joules per square meter	PRESSURE - Newton per square meter									
	13.6×10^4	68.0×10^4	1.7×10^6	3.4×10^6	5.8×10^6	10.3×10^6	13.6×10^6	20.6×10^6	27.2×10^6	34.0×10^6
1.07×10^5										
1.61×10^5										
2.11×10^5										
2.67×10^5										
3.16×10^5										
3.72×10^5										
4.28×10^5										
4.84×10^5										
5.33×10^5										
5.88×10^5										
6.38×10^5										
6.94×10^5										
7.72×10^5	0/5	0/20	0/20	0/20	0/20	0/20	0/20	0/20	0/20	0/20

WSTF Pressurized GOX Mechanical Impact Test Results

TABLE 48

MATERIAL : ALUMINUM 6061-T6

Plummet Wt.: 3.4 kg

Striker Pin Dia.: 0.63 cm

Test Atmosphere: 100% O_2

Sample Dia.: 0.63 cm

Sample Thickness: 0.16 cm

NUMBER OF REACTIONS/NUMBER OF TESTS

ENERGY IMPACT - Joules per square meter	PRESSURE - Newton per square meter									
	13.6 X 10^4	68.0 X 10^4	1.7 X 10^6	3.4 X 10^6	5.8 X 10^6	10.3 X 10^6	13.6 X 10^6	20.6 X 10^6	27.2 X 10^6	34.0 X 10^6
1.07 X 10^5										0/5
1.61 X 10^5										
2.11 X 10^5										
2.67 X 10^5										0/5
3.16 X 10^5										
3.72 X 10^5										
4.28 X 10^5										0/5
4.84 X 10^5										
5.33 X 10^5										
5.88 X 10^5										0/5
6.38 X 10^5										
6.84 X 10^5										
7.72 X 10^5										0/20

WSTF Pressurized GOX Mechanical Impact Test Results

TABLE 49

MATERIAL: ALUMINUM 6061-T6

Plummet Wt.: 3.4 kg **Sample Dia.:** 0.63 cm

Striker Pin Dia.: 0.63 cm **Sample Thickness:** 0.32 cm

Test Atmosphere: 100% O_2

NUMBER OF REACTIONS/NUMBER OF TESTS

ENERGY IMPACT - Joules per square meter	PRESSURE - Newton per square meter									
	13.6 X 10^4	68.0 X 10^4	1.7 X 10^6	3.4 X 10^6	6.8 X 10^6	10.3 X 10^6	13.6 X 10^6	20.6 X 10^6	27.2 X 10^6	34.0 X 10^6
1.07 X 10^5										0/5
1.61 X 10^5										
2.11 X 10^5										
2.67 X 10^5										0/5
3.16 X 10^5										
3.72 X 10^5										
4.28 X 10^5										0/5
4.84 X 10^5										
5.33 X 10^5										
5.88 X 10^5										0/5
6.38 X 10^5										
6.94 X 10^5										
7.72 X 10^5										0/20

TABLE 50 - WSTF GOX PNEUMATIC IMPACT TEST RESULTS

Sample Thickness: 0.16 cm

Sample Diameter: 0.48 cm

(NUMBER OF REACTIONS/NUMBER OF TESTS)

MATERIAL	PRESSURE - Newton per square meter									
	13.8×10^4	68.0×10^4	1.7×10^6	3.4×10^6	6.8×10^6	10.3×10^6	13.6×10^6	20.6×10^6	27.2×10^6	34.0×10^6
Viton PLV 50108							0/20	1/20		
Fluorel E2160	0/1	0/1	0/1	0/21	2/21	1/22	11/20			
Krytox * 240AC	0/1	0/1	0/1	0/21	1/20	1/18	1/5	1/1		
Aluminum 6061-T6										0/20
Teflon TFE									0/20	2/20
Fluorogold					0/20	1/20	1/3	1/6	1/2	
Fluorogreen EGOO								0/20	6/20	1/3
Rulon A						0/20	1/20	1/1		
Garlock 8573								0/2	0/20	1/20
Kel-F				0/20	1/20	1/5	1/12	1/2	1/1	
Nylon 6/6	0/1	0/1	0/1	0/1	10/20					
Vespel SP-21									0/20	4/20

* Samples were .0127 cm thick.

TABLE 51 - WSTF GOX PNEUMATIC IMPACT TEST RESULTS

Sample Thickness: 0.32 cm Sample Diameter: 0.48 cm

(NUMBER OF REACTIONS/NUMBER OF TESTS)

MATERIAL	PRESSURE - Newton per square meter									
	13.8×10^4	68.0×10^4	1.7×10^6	3.4×10^6	6.8×10^6	10.3×10^6	13.6×10^6	20.6×10^6	27.2×10^6	34.0×10^6
Viton PLV 5010B						0/20	1/20	1/2		
Fluorel E2160	0/1	0/1	0/1	0/1	0/20	1/20	1/1			
Krytox 240AC										
Aluminum 6061-T6										0/20
Teflon TFE						0/20	2/20	1/4	1/3	1/3
Fluorogold							0/20	3/20	1/1	
Fluorogreen E600					0/20	2/20	1/3	1/1		
Rulon A							0/5	0/5	0/20	2/20
Garlock 8573									0/20	2/20
Kel-F					0/20	1/20	1/8	1/1		
Nylon 6/6				0/20	13/20	5/5				
Vespel SP-21								0/20	2/20	1/6

TABLE 52 - WSTF FLASH POINT TEST RESULTS

0.16 cm Thick Samples

(Temperatures in ^{o}C)

MATERIAL	PRESSURE - Newton per square meter								
	13.8 X 10^4	34.0 X 10^4	68.0 X 10^4	1.7 X 10^6	3.4 X 10^6	6.8 X 10^6	10.3 X 10^6	13.8 X 10^6	20.8 X 10^6
Viton PLV 50108	418	399	386	370	371	365	358	347	337
Fluorel E2160	427	421	408	384	378	342	332	324	317
Krytox* 240AC	> 537	> 537	484	467	461	458	453	439	439
Aluminum 6091-T6	> 537	> 537	> 537	> 537	> 537	> 537	> 537	> 537	> 537
Teflon TFE	> 537	507	502	496	491	485	467	461	453
Fluorogold	490	482	478	474	469	459	431	434	424
Fluorogreen E800	> 537	534	518	514	504	498	494	489	488
Rulon A	> 537	503	500	496	517	512	504	**	
Garlock 8573	> 537	478	473	465	461	460	441	436	431
Kel-F	429	405	409	416	413	412	410	413	422
Nylon 6/6	384	357	342	307	263	219	**		
Vespel SP-21	> 537	528	527	518	**				

* 0.5 gm of Lubricant.

** Series terminated due to potential damage to test apparatus.

TABLE 53 - WSTF FLASH POINT TEST RESULTS

0.32 cm Thick Samples

(Temperatures in °C)

MATERIAL	PRESSURE - Newton per square meter								
	13.8 X 10^4	34.0 X 10^4	68.0 X 10^4	1.7 X 10^6	3.4 X 10^6	6.8 X 10^6	10.3 X 10^6	13.8 X 10^6	20.6 X 10^6
Viton PLV 50108	423	394	382	379	356	356	346	344	323
Fluorel E2160	426	417	399	376	362	332	324	319	311
Krytox 240AC									
Aluminum 6061-T6	>537	>537	>537	>537	>537	>537	>537	>537	>537
Teflon TFE	>537	511	497	481	474	465	462	479	454
Fluorogold	>537	475	462	455	452	441	433	433	*
Fluorogreen E800	>537	>537	523	521	514	503	498	497	488
Rulon A	>537	504	498	493	510	506	*		
Garlock 8573	>537	486	482	474	462	448	451	437	455
Kel-F	401	413	403	408	414	413	413	414	416
Nylon 6/6	374	363	314	275	256	*			
Vespel SP-21	>537	>537	>537	537	*				

* Series terminated due to potential damage to test apparatus.

TABLE 54 - WSTF FIRE POINT TEST RESULTS

0.16 cm Thick Samples

(Temperatures in °C)

MATERIAL	PRESSURE - Newton per square meter								
	13.8 X 10^4	34.0 X 10^4	68.0 X 10^4	1.7 X 10^6	3.4 X 10^6	6.8 X 10^6	10.3 X 10^6	13.8 X 10^6	20.8 X 10^6
Viton PLV 50108	418	399	386	370	371	365	358	347	337
Fluorel E2180	431	421	408	384	378	342	332	324	317
Krytox * 240AC	>537	>537	484	467	461	458	453	439	439
Aluminum 6061-T6	>537	>537	>537	>537	>537	>537	>537	>537	>537
Teflon TFE	>537	512	502	496	491	485	467	461	453
Fluorogold	490	482	478	474	469	459	431	432	424
Fluorogreen E600	>537	534	518	514	504	498	494	489	488
Rulon A	>537	503	500	496	517	512	504	**	
Garlock 8573	>537	478	473	465	461	460	441	436	431
Kel-F	429	405	409	416	413	412	410	413	422
Nylon 6/6	384	357	342	307	263	219	**		
Vespel SP-21	>537	528	527	518	**				

* 0.5 gm of Lubricant

** Series terminated due to potential damage to test apparatus.

TABLE 55 - WSTF FIRE POINT TEST RESULTS

0.32 cm Thick Samples

(Temperatures in ^{o}C)

MATERIAL	PRESSURE - Newton per square meter								
	13.8×10^4	34.0×10^4	88.0×10^4	1.7×10^6	3.4×10^6	6.8×10^6	10.3×10^6	13.8×10^6	20.8×10^6
Viton PLV 50108	423	394	382	379	356	356	346	344	323
Fluorel E2180	433	417	400	376	362	332	324	319	311
Krytox 240AC									
Aluminum 6061-T6	>537	>537	>537	>537	>537	>537	>537	>537	>537
Teflon TFE	>537	511	497	481	474	465	462	479	454
Fluorogold	>537	475	462	455	452	441	433	433	*
Fluorogreen E600	>537	>537	523	521	514	503	498	497	488
Rulon A	>537	504	498	493	510	506	*		
Garlock 8573	>537	486	482	474	462	448	451	437	455
Kel-F	401	413	403	408	414	413	413	414	416
Nylon 6/6	374	363	314	275	256	*			
Vespel SP-21	>537	>537	>537	537	*				

* Series terminated due to potential damage to test apparatus.

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